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Preface

We would like to present, with great pleasure, the inaugural volume-5, Issue-1, January 2019, 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

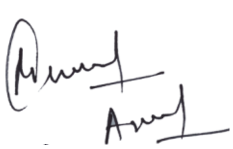
Environmental Research:

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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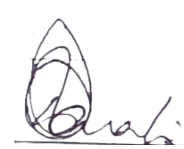

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Agricultural Sciences	
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Dr. Salvinder Singh

Presently working as Associate Professor in the Department of Agricultural Biotechnology in Assam Agricultural University, Jorhat, Assam.

Dr. Salvinder received MacKnight Foundation Fellowship for pre-doc training at WSU, USA – January 2000- March 2002 and DBT overseas Associateship for Post-Doc at WSU, USA – April, 2012 to October, 2012.

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Dr. Deshmukh Amol Jagannath

Presently working as Assistant Professor in Dept. of Plant Pathology, College of Agriculture polytechnic, NAU, Waghai.

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Productive behavior of cultivars and banana genotype originating from 'Prata Anã', Irrigated and non irrigated in the State of Minas Gerais, Brazil

Lair Victor Pereira[1], José Clélio de Andrade[2], Ângelo Albérico Alvarenga[3], Marcelo Ribeiro Malta[4], Paulo Márcio Norberto[5], Gil de Faria Leite[6], Sebastião de Oliveira e Silva[7]

[1,2,3,4,5]Searchers from the Agricultural Research Company of Minas Gerais – EPAMIG, Campus UFLA, PO Box 176, Lavras - MG (BRAZIL) 37200-000

[6]Teacher at the Federal Institute of Minas Gerais - IFMG - Bambui - MG (BRAZIL) 38900-000

[7]PVNS / Capes / UFRB, Cruz das Almas - BA (BRAZIL) 44380-000

***Abstract*— *The objective of this work was to evaluate the vegetative and productive behavior of banana cultivars Prata Catarina and PrataGorutuba, from clonal selection in cultivars of Prata-Anã and BRS Maravilha and PA 94-01, obtained through crosses of the genotype SH 31-42 with Prat-Anã and Prata Catarina, respectively. The experiment was conducted in Bambuí under drip irrigation and in Iaci, without irrigation. A randomized complete block design with four replications was used for each cultivar and plots with ten plants, spacing 3.0 x 2.8 m (1190 plants / hectare). The vegetative behavior was evaluated through the plant height (m) at the time of the bunch issue and the production cycle, that is, the period between planting and harvesting of the mother, daughter and granddaughter plants. The productive behavior was evaluated by bunch weight (kg) and fruit (g) and number of fruits per bunch and yield (kg / ha / year). The data were submitted to analysis of variance and the means compared by the Tuckey Test at 5% probability. The 'BRS Maravilha' showed the highest height of the plant, both in Bambuí and in Ijaci. The other cultivars did not differ in height. PA 94-01 was earlier in both locations, with a production cycle about one month less than the other cultivars. The cultivar BRS Maravilha and PA 94-01 surpassed the others by weight of the bunch and the fruits, number of fruits per bunch and yield in the two localities, and in Bambuí was significantly higher than in Ijaci, thus showing the expressive effect of irrigation. The PA 94-01, due to its good productivity, fruit size, appearance, taste and precocity can become a better option for the producers compared to the other cultivars.*

***Keywords*— Banana, Productivity, Precocity, Quality.**

I. INTRODUCTION

Banana is the most produced fruit in the world, with an average of 106.5 million tons. Among the most consumed fruits in nature marketed in the world, the banana presents greater financial movement, followed by grape, apple and orange. (FOCORURAL, 2018). Throughout the world, more than 125 countries are engaged in banana cultivation. In some, the activity stands out as one of the main sources of employment and income (VIEIRA, 2015; REINHARDT, 2016).

In Brazil, climatic conditions allow bananas to be grown in all states throughout the year, taking into account domestic demand. The Brazilian banana production was 6.76 million tons, with the main producers São Paulo, with 1.079 million tons; Bahia, with 1,084 million tons; Minas Gerais, with 773 thousand tons; Pará, with 504 thousand tons, and the other states with 2,590 million tons, (Andrade et al., 2017).

In the Brazilian banana market the most common cultivars are 'Prata' (subgroup Silver), 'Nanica' (Cavendish subgroup), 'Apple', 'Terra', 'Gold' and 'Marmelo'. In terms of cultivated area in Minas Gerais, the Silver type occupies 80.0%, nanica 15.0% and Apple 5.0% (MINAS ..., 2017).

Among the cultivars of the Prata type, the cultivar 'Prata-Anã' is more cultivated in the state of Minas Gerais. However, due to their susceptibility to Panama's Evil and the black and yellow Sigatoka, new cultivars have been obtained through genetic improvement and recommended to growers. Thus, cultivars PrataGorutuba and Prata Catarina, obtained through clonal selection in 'Prata-Anã' plantations and the 'BRS Maravilha' obtained through a cross between 'Prata-Anã' and SH 3142 have been recommended for superior agronomic characteristics her mother. Among these characteristics, the highest tolerance to these diseases, in addition to greater productivity and similarity of fruits in flavor, appearance and size with those of 'Prata-Anã' (SILVA et al., 2008), stand out.

The 'BRS Maravilha' was introduced from Honduras and recommended by Embrapa (Brazilian Agricultural Research Company) and PA 94-01 genotype obtained by EmbrapaMandioca and Tropical Fruit through the cross between 'PrataAnã', 'Prata Catarina' and SH These two cultivars present productivity far superior to their genitor, as well as greater tolerance to diseases and edafoclimatic adaptation (DONATO et al., 2009). (SANTOS and CARNEIRO, 2012), in Goiânia - Goiás (MENDONÇA et al., 2013), in Aquidauana - Mato Grosso (VIEIRA, 2011), in Botucatu - SP (RAMOS et al., 2009) and in Lavras - MG (Pereira et al., 2003). In irrigated conditions 'BRS Maravilha' was more productive than 'Prata-Anã' in the Jaíba Projects (RODRIGUES et al., 2006) and Gorutuba (SOUTO et al., 2001).

Among the cultivars of the Prata-Anã variety of Prata, evaluated in Lavras-MG, genotype PA 94-01 was the one that produced larger bunches in weight and number of fruits, being similar in aspect, size and flavor of the his father 'Silver-Anã' (PEREIRA et al, 2016).

The cultivar Prata Catarina was similar in size, production cycle, fruit characteristics and produced bunches about 23.0% higher than 'Prata-Anã' in eleven localities of the State of Santa Catarina (EPAGRI, 2016).

Regarding the cultivar PrataGorutuba, there is no report of research results on its productive and vegetative behavior. However, there are already large areas cultivated with this cultivar, mainly in the northern region of Minas Gerais. In this region it has presented greater production and tolerance to the Mal-do-Panama (RODRIGUES, 2014)

The objective of this work was to evaluate the productive and vegetative behavior of banana cultivars originating from the cultivar Prata-Anã under irrigated and dry conditions.

II. METHODOLOGY

The evaluation of the vegetative and productive behaviors of four banana cultivars originating from 'Prata-Anã' cultivar was carried out in Bambuí and Ijací, in the Center-West and Southern regions of Minas Gerais, Brazil.

The Bambuí test was conducted in the premises of the Federal Institute of Minas Gerais, Bambuí Campus, during the period from December 5, 2014 to December 31, 2017, with irrigation through drip hoses from May to August of each year. The Ijaci test was conducted in dry conditions during the same period.

40 cm high tissue culture seedlings were used, which had previously been transplanted into 12 x 30 cm plastic bags containing soil, manure and sand in the ratio 2: 1: 1, in addition to fertilization with NPK (20- 05-20)

In the two trials the following cultivars were evaluated: Prata Catarina and PrataGorutuba, obtained through clonal selection in 'Prata-Anã' cultivars in the States of Santa Catarina and Minas Gerais, respectively. The cultivar BRS Maravilha) was obtained through the cross between 'Prata-Anã' (AAB) and SH 31-42 (AA) and the genotype PA 94-01 through the cross between 'Prata Catarina' and SH 31-42. The cultivar Prata-Anã, being the most cultivated in Minas Gerais, was included as a witness.

Bambuí is situated at 729 meters of altitude, at 20o 00 '21' 'south latitude and 45o 58' 37 " west longitude. Its soil is classified as Latosol dark red. Ijaci is at 889 meters of altitude, and at 21o 10 '12' 'south latitude and at 44o 55' 30 " west longitude and soil classified as ferric red Latossolo.

The climate of the two localities is according to the classification of Koppen (DANTAS; CARVALHO; FERREIRA, 2007) is cwa, that is, temperate rainy (mesothermic) with dry winter and subtropical rainy summer.

The data of annual rainfall mean maximum, minimum and average temperature and relative humidity of the air of 2015, 2016 and 2017 of Ijaci and Bambuíare presented in Table 1.

TABLE 1
ANNUAL RAINFALL AND ANNUAL AVERAGES OF RELATIVE HUMIDITY, MAXIMUM TEMPERATURES, MINIMUM TEMPERATURES, MEAN TEMPERATURES OF THE MUNICIPALITIES OF IJACI AND BAMBUI, MINAS GERAIS, BRAZIL, FROM 2015 TO 2017

Climatevariables / years	Ijaci			Bambui		
	2015	2016	2017	2015	2016	2017
Precipitation (mm)	1.341	1.215	985	1.256	1.205	1.030
Relativehumidity (%)	71,3	70,8	69,2	68,5	70,6	69,6
Maximumtemperature (°C)	27,7	27,9	27,4	28,9	29,1	28.1
Minimumtemperature(ºC)	16,5	16,2	15,7	16,0	17,1	16,5
Meantemperature(ºC)	21,3	21,0	20,9	21,8	21,5	21,4

According to the monthly rainfall data, both in Ijaci and Bambui, the driest months in the years 2015 to 2017 were from May to September, below 30mm / month. From April to August, the maximum, minimum and average temperatures were below 27ºC, 15ºC and 20ºC, respectively.

The vegetative behavior was evaluated through plant height (m), using the average of the first three cycles (mother, daughter and granddaughter) and the production cycle, that is, the period of months from planting to harvesting of the mother plants, daughter and granddaughter. The height was taken at the time of the bunch issue and the insertion of the bunch in the pseudocaule.

The productive behavior was evaluated by the weight of the bunch and the fruits, number of fruits per bunch and size of the fruits (length and diameter). The weight and size of the fruits were taken from the middle portion. The data referring to the productive behavior are averages of the first three production cycles.

The planting of the seedlings was done in spacing 3.0 x 2.8 m (1,190 plants / hectare), being 10 plants per plot in four replications for each cultivar. It was used the design in randomized blocks. The data were submitted to analysis of variance and the means compared by the Tuckey Test at 5% probability.

III. RESULTS AND DISCUSSION

According to the data in Table 2, it is observed that BRS Maravilha plants showed significantly higher height than the other cultivars in both Ijací and Bambuí. It is also observed an increase in plant height around 30 cm from the mother plant to the daughter plant and from that to the net plant at both sites. This increase in plant height at each generation is reported by Rodrigues et al. (2006) and Silva et al. (2003) and only stabilizes in more advanced generations.

In the Ribeira Valley without irrigation, the BRS Maravilha variety also presented plant height significantly higher than 'Prata-Anã' and PA 94-01 (NOMURA et al., 2013), as well as in the Jaíba Project in relation to 'Prata -Anã '(RODRIGUES et al., 2006).

In Bambuí, under irrigated conditions, all cultivars showed higher height of mother, daughter and granddaughter plants, about 50 cm in Ijací, under dry conditions. This result is corroborated by the report by Costa et al. (1999), where the authors state that the establishment period and the initial phase of vegetative development of the banana tree determine the growth potential and fruiting, being essential the water and nutrients supply. Turner; Fortescue; Thomas, 2007, also state that banana is very sensitive to water deficit and, therefore, water is the abiotic factor most limiting to production.

In the technical data sheet of the 'PrataGorutuba' plant, it mentions a height of 2.5 to 3.0 m in the mother plant cycle, a mean bunch weight of 20 to 24 kg, with a productivity of 32 to 35 t / ha, to 'Prata-Anã' (RODRIGUES et al., 2014).

On the other hand, with respect to 'Prata Catarina', the only reference (EPAGRI, 2016) only mentions about average weight of the bunch in Itajai - SC and Urussanga - SC, medium size, medium precocity, medium size fruits, high susceptibility to yellow Sigatoka and moderate resistance to Mal-do-Panama.

The height of the mother plant and daughter of the cultivars Maravilha, PrataAnã and PA 94-01 in dry conditions in Ijaci was higher than in Lavras (PEREIRA et al., 2003) and lower than in the Ribeira Valley (NOMURA et al. , 2013). The highest height in the Ribeira Valley, state of São Paulo, Brazil, can be attributed to temperature and relative humidity of the highest air and soil fertility.

The highest plant height of the cultivars BRS Maravilha and Prata-Anã in Bambuí in relation to Jaíba can be attributed to several factors, such as: type and size of seedlings, soil fertility and distribution of rainfall in the months subsequent to planting.

TABLE 2
MEAN HEIGHT VALUES OF MOTHER, DAUGHTER AND GRANDDAUGHTER OF BANANA CULTIVARS ORIGINATING FROM 'PRATA-ANÃ' IN BAMBUÍ AND IJACI, MG, BRAZIL

Cultivars	Planthight (m)					
	Bambui			Ijaci		
	Mãe	Filha	Neta	Mãe	Filha	Neta
Maravilha	3,06aA	3,50aB	3,85aC	2,55aA	3,06aB	3,52aC
PA 94-01	2,90bA	3,22bB	3,57bC	2,32bA	2,73bB	3,01bC
Prata Gorutuba	2,79bA	3,08bB	3,40bC	2,28bA	2,58bB	2,93bC
Prata Catarina	2,78bA	3,09bB	3,41bC	2,29bA	2,60bB	2,95bC
Prata-Anã	2,80bA	3,12bB	3,45bC	2,31bA	2,62bB	2,94bC
CV	11,12	9,88	9,16	12,76	10,06	9,31

Means followed by the same lowercase letter in the column and upper case in the line do not differ from each other by the Tuckey Test at 5% probability.

Regarding the production cycle, Table 3 shows that the cultivar PA 94-01 was earlier than the other cultivars in the three generations evaluated (mother, daughter and granddaughter). Both in Bambuí and Ijaci, there was no significant difference in the production cycle of cultivars BRS Maravilha, Prata Catarina, PrataGorutuba and Prata-Anã, independent of the generation or local.

The similarity in the production cycle of these cultivars may be due to the degree of kinship between them and the uniformity of the seedlings, soil fertility, among other factors. The higher precocity of PA 94-01 can be attributed to genetic factors inherited from its parent. However, in the Ribeira Valley, state of São Paulo, this cultivar had a production cycle significantly higher than 'BRS Maravilha' and 'Prata-Anã' than in Bambuí and Ijaci. In Guanambi, state of Bahia, the production cycle of the mother plants and daughters of the cultivars BRS Maravilha and PA 94-01, did not differ from that of Prata-Anã (DONATO et al., 2009).

Another factor worth mentioning is the production cycle of PA 94-01's daughter plant in the Ribeira Valley (NOMURA et al., 2013), about four months longer than in Bambuí and Ijaci. This discrepancy may be due to the type, size, uniformity of seedlings and planting season.

In Lavras, Minas Gerais, Brazil, the production cycle of cultivars BRS Maravilha, PrataAnã and PA 94-01 was similar (PEREIRA et al., 2016). In the Jaiba (RODRIGUES et al., 2006), the 'BRS Maravilha' cycle was one month larger than the 'Prata-Anã' cycle, but significantly lower than in the Ribeira Valley, Guanambi, BA, Lavras, Bambuí and Ijaci, MG. This lower cycle in Jaíba may be due to fertiirrigation, higher temperature and luminosity, lower altitude, among other factors.

Regarding the production cycle of the cultivars Prata Catarina and PrataGorutuba, there is little information in the literature. The 'Silver Catarina', according to EPAGRI (2016), presents medium precocity, similar to that of Prata-Anã.

The 'PrataGorutuba', in the region of the irrigated perimeter of the Jaíba Project, has presented the same production cycle of PrataAnã (RODRIGUES et al., 2014). This information corroborates the results obtained in Ijaci and Bambuí, that is, the similar production cycle of the cultivars Prata Catarina, PrataGorutuba and Prata-Anã.

In Goiânia, Goiás, the production cycle of the cultivars BRS Maravilha, Prata-Anã and PA 94-01, not irrigated, was around 16.3 and 15.2 months, respectively. It was significantly lower than in Ijaci and Bambuí, a fact that can also be attributed to higher temperatures and rainfall and lower altitude, as well as other factors such as: soil fertility and crop management. It should be noted that the effect of altitude is related to several climatic factors, such as: temperature, rainfall, relative humidity, luminosity, among others, which influence the development and production of the banana tree (ALVES et al., 1999).

TABLE 3
MEAN VALUES OF PRODUCTION CYCLES OF MOTHER, DAUGHTER AND GRANDDAUGHTER OF BANANA CULTIVARS ORIGINATING FROM 'PRATA-ANÃ' IN BAMBUÍ AND IJACI, MG, BRAZIL.

Cultivars	Productioncycle (months)					
	Motherplant		Daughterplant		Net plant	
	Bambui	Ijaci	Bambui	Ijaci	Bambui	Ijaci
PA 94-01	17,00aA	17,90aB	23,82aA	24,80aB	30,32aA	31,25aB
Maravilha	17,82bA	18,71bB	24,78bA	25,67bB	31,48bA	32,36bB
Prata Catarina	17,85bA	18,74bB	24,80bA	25,82bB	31,60bA	32,58bB
Prata Gorutuba	17,88bA	18,76bB	24,81bA	25,83bB	31,64bA	32,59bB
Prata-Anã	17,90bA	18,80bB	24,87bA	25,88bB	31,72bA	32,68bB
CV	12,44	13,16	10,33	10,84	8,56	9,26

Means followed by the same lowercase letter in the column and upper case in the line do not differ from each other by the Tuckey Test at 5% probability.

The cultivars BRS Maravilha and PA 94-01 were superior to Prata Catarina, Gorutuba and Prata-Anã in the weight of the bunch and fruit, number of fruits per bunch and yield in Bambuí and Ijaci. Only in number of fruits per bunch PA 94-01 was superior to BRS Maravilha in both places.

The cultivars Prata Catarina and Gorutuba did not differ from Prata-Anã by weight of the bunch and fruit, number of fruits per bunch and yield in the two sites.

The cultivar BRS Maravilha produced fruits significantly larger than the others, a characteristic not widely accepted in the retail market.

The fruits of cultivar PA 94-01, although larger than the cultivars Prata-Anã, Prata Catarina and PrataGorutubaare well accepted by consumers due to their similarity in appearance and taste with those of the Silver type.

In terms of bunch weight and yield, cultivars BRS Maravilha and Prata-Anã were superior in Jaíba (RODRIGUES et al., 2006) compared to the results of Bambuí, both trials being conducted with irrigation. This superiority in Jaíbacan be attributed to water supplementation through microaspersion fertiirrigation. Other factors that may have contributed to higher production in Jaíba are higher temperature and luminosity and lower altitude (ALVES et al., 1999).

The mean weight of the bunch and fruit, yield and number of fruits per bunch, independent of the cultivar, was about 60% higher in Bambuí, a fact attributed mainly to irrigation.

TABLE 4
MEAN VALUES OF BUNCH AND FRUIT WEIGHT, YIELD AND NUMBER OF FRUITS PER BUNCH OF BANANA CULTIVARS ORIGINATING FROM 'PRATAANÃ' IN BAMBUÍ AND IJACI, MG, BRAZIL

Cultivars	Bunchweight (kg)		Weight of the fruit (g)		Yield (t / ha / year)		Nº offruits / bunch	
	Bambui	Ijaci	Bambui	Ijaci	Bambui	Ijaci	Bambui	Ijaci
Maravilha	34,15aA	20,80aB	212,08aA	158,70aB	40,63aA	24,75aB	161,08bA	131,06aB
PA 94-01	27,02bA	17,44bB	149,22bA	126,61bB	32,15bA	20,70bB	181,00aA	137,75aB
Prata Catarina	17,12cA	11,13cB	129,50cA	105,42cB	20,37cA	13,55cB	132,20cA	113,29bB
Prata Gorutuba	16,90cA	11,06cB	127,20cA	104,30cB	20,11cA	13,60cB	128,50cA	110,40bB
Prata-Anã	16,29cA	10,87cB	124,12cB	101,12cB	19,40cA	13,41cB	125,93cA	107,36bB
CV	10,23	12,61	8,48	11,63	11,88	13,55	10,12	13,88

Means followed by the same lowercase letter in the column and upper case in the line do not differ from each other by the Tuckey Test at 5% probability.

The values of each variable in each location refer to the average of the first three cycles, ie, mother, daughter and granddaughter plants.

The productivity of the banana industry is 22.13 t / ha and 23.63 t / ha for the irrigated production of the North and Northwest regions of Minas Gerais, respectively, and from 14.08 and 12.79 t / ha for the South and Mata regions of Minas Gerais, with non-irrigated production. It should be noted that the average productivity of Minas Gerais is 17.68 t / ha (SEAPA, 2017).

The BRS Maravilha and PA 94-01 non-irrigated cultivars in Goiânia (MENDONÇA et al., 2013) produced smaller weights than in Bambuí, irrigated, higher than in Ijaci, not irrigated, including the cultivar PrataAnã. The production of larger clusters in Bambuíshould be attributed to irrigation, whereas the greater production of Goiânia in relation to Ijaci can be attributed to higher temperature, luminosity and humidity (ALVES et al., 1999), besides the management and soil fertility.

The production of BRS Maravilha and PrataAnã, irrigated was significantly higher in Bambuí - MG than in Guanambi - BA (DONATO et al., 2003), whereas in Ijaci - MG, not irrigated, the BRS Maravilha production was much larger than it is and the Dwarf Silver, smaller. This discrepancy in production at the three sites can be attributed to climate, soil fertility and crop management (ALVES et al., 1999).

There are few research results on the cultivars PrataGorutuba and Prata Catarina. The Gorutuba Silver was selected at 'Prata-Anã' planting in Janaúba, Jaíba and Verdelândia, at the irrigated perimeter of the North of Minas Gerais, where the average productivity was 35 t / ha from the third cycle, plant height of 3.0 m. The cultivar Prata Catarina was selected in plantations of PrataAnã, produced bunches with an average weight of 21.15 kg in Itajaí - SC and 17.55 kg in Urussanga - SC in the harvest from 2010 to 2012. On the other hand, cultivars Prata -Anã and BRS Maravilha also produced bunches with a mean weight of 15.8 kg and 28.85 kg, respectively, in the second crop. Other advantages of the 'BRS Catarina' are its resistance to nematoids and moderate resistance to Panama's Evil and medium-sized.

In addition to the higher productivity of 'BRS Maravilha' and PA 94-01, these cultivars have greater resistance to black and yellow Sigatoka and to Mal-do-Panama (SILVA et al., 2008). Other important aspects to consider are the size and the fruit size, appearance and flavor similar to that of the 'Prata-Anã', the most cultivated and commercialized in the state of Minas Gerais and Brazil.

IV. CONCLUSION

- Irrigation provided an increase of about 60% in the production of all cultivars and the genotype;
- The genotype PA 94-01 produces fruits similar in size, appearance and flavor to the cultivars Prata Catarina, PrataGorutuba and Prata-Anã;
- The cultivar BRS Maravilha and genotype PA 94-01, originated from the hybridization improvement, are more productive than those of the clonal selection of the cultivars Prata Catarina, PrataGorutuba and Prata-Anã.

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Towards Attainment of Sustainable Rural Livelihoods and Poverty Reduction among Rural Farmers: Whither Farm Waste Utilization?

Yusuf, O. J.[1]; Adisa, B. O.[2]; Subair, S. K.[3]

[1,3]Department of Agricultural Economics and Extension Service, Kwara State University, Nigeria
[2]Department of Agricultural Extension and Rural Development, Obafemi Awolowo University, Ile-Ife, Nigeria

Abstract— *The study investigated potential of farm wastes' utilization for attaining sustainable livelihoods and reducing poverty among rural dwellers in Osun state, Nigeria. Specifically, socioeconomic attributes of the respondents were described and significant determinants of farm waste utilization identified. Primary data were collected using interview schedule collected from 364 respondents sampled for the study through multi stage procedure. Frequency counts, percentages, mean and standard deviation were used to describe data collected. Rational choice theory and theory of planned behaviour were used to provide theoretical underpinning for the study. Multiple linear regression analysis was used to identify significant determinants of farm waste utilization. Result showed that cassava and yam peels, maize stalks and cobs, cowpea husk, palm kernel shell, empty palm fruit bunch, cocoa pods, poultry droppings, sheep and goat faeces were amongst farm wastes with economic potentials in the study area. Result of regression analysis showed that income (t = 2.401), perception about farm waste items (t = 4.458), perceived behavioral control (t = 2.534) and attitude towards farm waste utilization (t = 2.732) positively and significantly contributed to extent of farm waste utilization, while total farm size (t = 1.988) and years spent on formal education (t = 2.024) positively and significantly contributed to extent of farm waste utilization at $p \leq 0.05$. However, information sources (t = -2.732) and knowledge about farm waste utilization potentials (t = -2.314) significantly but negatively influenced farm waste utilization $p \leq 0.05$, respectively. It was concluded that varieties of farm waste items with good economic potentials for utilization abound in the study area. In order to empower rural dwellers economically thereby enhancing their livelihoods and ameliorating their poverty condition, paying attention to the significant determinants of waste utilization identified is recommended.*

Keywords—Farm wastes, Theory of Planned Behaviour, Sustainable livelihoods, Economic empowerment.

I. INTRODUCTION

Agricultural activities are generally known to generate waste materials during crop growth and harvest. Similarly, livestock farming experiences a large volume of by-products in terms of urines and faeces. Wastes are also generated during the extraction of raw materials, the processing of raw materials into intermediate and final products and the consumption of final products. According to Afolayan *et al*. (2012), various scientists estimated waste generation in Nigeria at 0.58 kg/person/day, which is further breakdown as follows: municipal solid waste – 4,075 million tons, fuel wood - 38.1million tons, agro waste-11.24 million tons with sawdust at 1.8 million tons. The above estimations is with little or no consideration for the rural dwellers that constitute more than 53% of over 170 million population of the country, whom farming is their primary occupation.

Many rural farm families make a living from a variety of livelihood choices ranging from cultivation of arable and tree crops and rearing of livestock to trading and agro-processing amongst others. Several farm residues generated in the process, in conventional practices, are generally treated in uncontrolled manner, by either burning in open-air fires or thrown away to decay. This burning or decomposition, apart from amounting to a colossal waste of resources, contributes to environmental degradation and pollution which is hazardous to both human and ecology. So, many rural dwellers conventionally made their livelihood choices without considering a full utilization of these items, despite the invaluable potentials and availability of these items. Rather, they often focus more on major produce/product of their cultivation/processing, with the farm residue often regarded as waste items and discarded with their vast potentials left untapped or underutilized (Yusuf, 2014).

The notions of discarding waste, simply through burning or decomposition, are now changing. There is current spate of transformation which presents new choices and opportunities, and provides lessons and pointers for industrial, social and environmental policy in the new post-industrial landscape. Three basic drivers of this change which are now turning waste and waste management into a dynamic, fast-changing, international economic sector include: growing concern about the hazards of waste disposal; broader environmental concerns, especially global warming and resource depletion; and economic opportunities created by new waste regulations and technological innovation (Murray, 1999).So the concept of waste as a material "which has no use" is changing to that of "a resource" by converting into useful materials with necessary modifications (Kumar and Grover, 2007).

So, materials often regarded as wastes by rural inhabitants could constitute part of natural asset base within the rural environment that can be convertible to important local resources. They should be regarded as by-products which exploitation could enhance sustainable livelihood diversification and facilitate economic empowerment of the rural populace. For instance, biomass briquettes, mostly made of green waste and other organic materials, such as rice husk, ground nut shells, could be used for electricity generation, heat and cooking fuel in the rural areas. Sadly, however, big trees, protecting the ecosystem, are massively cut down in order to make coal to meet energy needs, thereby worsening environmental degradation. The dependence on traditional charcoal and firewood, Sabiiti (2011) noted, contributes to the prevailing deforestation and soil degradation, the effects of which have manifested in irregular rainfall, floods and violent storms.

There is inadequate knowledge about waste generation and composition in rural areas globally because these types of studies have been conducted mainly in big cities, noted Taboada-González *et al*. (2010). Also, many scholarly writings on waste materials emphasize mainly the environmental and hardware-technological aspects of wastes, with less attention to the affective domain (Jekayinfa and Omisakin, 2005; Oyeleke and Jibrin, 2009; Oladeji, 2011). It is also important to note that what a society regards as 'waste' is intensely socially construed. People in different cultures or even in different tribes within the same culture may value same things differently. In essence, what may be covert-waste to some may be deemed overt-resource to others. These thus underscore the necessity for sociological inquiry about farm waste generation and utilization. On this premise, the authors draw on rational choice theory and theory of planned behavior to provide theoretical underpinning for the study.

II. PURPOSE OF THE STUDY

The general objective of the study was to examine the roles of farm waste utilization towards attainment of sustainable livelihoods and poverty reduction amongst rural dwellers in Osun State, Nigeria. The specific objective was to describe key socio-demographic attributes of respondents and identify significant determinants of farm waste utilization among the respondents.

III. THEORETICAL FRAMEWORK

3.1 Rational choice theory

Sociologists have tried to build theories around the idea that all action is fundamentally 'rational' in character and that people calculate the likely costs and benefits of any action before deciding what to do. This approach to theory is known as rational choice theory (Scott, 2000). There are two main elements in the theory – actors and resources. Actors are seen as being purposive, or as having intentionality. That is actors have ends or goals towards which their actions are aimed. Actors are also seen as having preferences (values), and of importance to rational choice theory is that actions are taken to achieve objectives that are consistent with actors' preference hierarchy. Resources are those things over which actors have control and in which they have some interest (Ritzer and Stepnisky, 2014).

According to Heckathorn (1997), two other ideas that are basic to rational choice theory as mentioned by Friedman and Hechter are aggregation mechanism and importance of information. Aggregation mechanism is the process by which "separate individual actions are combined to produce the social outcome". The second idea, which has more relevance and bearing to this study, is the importance of information in making rational choices. At one time, it was assumed that actors had perfect, or at least sufficient, information to make purposive choices among the alternatives courses of actions open to them. However there is growing recognition that the quantity or quality of information is highly variable and that that variability has profound effect on actors' choices (Heckathorn, 1997).

Following the premise of the rational choice theory, rural dwellers who are the 'actors' (subject of focus) in this study would 'rationally' seek to utilize farm waste items given that there is assurance of a profitable economic outcome as a result. As such whether an individual within the rural environment would regard a particular farm waste item as important local resource and subsequently make use of it would depend largely on what he stands to gain in terms of economic benefit derivable there from. In addition, the availability of 'qualitative information' about farm wastes utilizations' potentials could significantly influence and sustain rural dwellers' decision to engage in farm waste utilization.

3.2 Theory of planned behavior

The theory of planned behavior developed by Ajzen in 1985 posits that human behavior is largely influenced by the very intention to carry out the behavior. Intentions reflect the motivational factors that influence that behavior. They are indications of how much people are willing to try, and how much effort they are planning to invest in order to carry out the behavior in question (Ajzen, 1991). Furthermore, the theory posits that intentions themselves are determined by 'perceived behavioral control (PBC), ‘attitude’ and the ‘subjective norm’. PBC refers to people’s confidence in their ability to perform the behavior, as well as to their perception of how easy or difficult it is to carry it out. Attitude refers to a person’s disposition to respond favorably or unfavorably towards behaviour. It is a hypothetical construct, that being inaccessible to direct observation, must be inferred from measurable responses. SN refers to the person’s perceived social pressure to perform the behavior or not. In other words, it reflects whether the individual perceives that a significant number of people endorse/disapprove the behavior of interest. Overall, the more favorable the attitude and subjective norm and the higher the PBC, the greater the willingness (intention) to perform that behavior of interest (Ajzen, 1991).

The Theory of Planned Behavior (TPB) (Ajzen, 1991) provides a theoretical framework for systematically investigating factors which influence behavioral choices. Several studies have applied the TPB to investigate waste recycling and reuse behaviors. These include: Tonglet *et al.* (2004), which investigated determinants of recycling behavior in Brisworth, UK; Zhou (2010) which sought to determine sustainable waste management practices in College and University dining services in Kansas, and Ho (2002) where Singaporean’s household waste recycling behavior was understudied, with a view to ascertaining recycling as a sustainable waste management strategy for Singapore. So, the TPB is found suitable for use in this study because of its perceived adequateness and applicability in encapsulating the key variables that are significant determinant of farm waste utilization.

IV. METHODOLOGY

The study was conducted in Osun State, Nigeria. There are three agro-ecological zones of the state Agricultural Development Project (ADP), namely: Osogbo (derived savannah) zone, Ife/Ijesha (rainforest) zone and Iwo (savannah) zones which have 13 Local Government Areas (LGAs), 10 LGAs and 7 LGAs, respectively. A multistage sampling procedure was used to select the respondents sampled for the study. At the first stage, 20 per cent of the total number of LGAs in each zone was used to select three, two and one rural LGAs, respectively, from the three zones. These were: Odo-otin, Egbedore, Orolu LGAs, from Osogbo zone; Atakumosa west and Ife south LGAs from Ife/Ijesha zone and Ayedade LGA from Iwo zone. At second stage, using proportionate sampling, five per cent of the total number of communities in each LGA was used to select 28 communities. Finally, 13 respondents involved in farm waste utilization were purposively chosen from each of the selected communities, giving a sample size of 364 respondents.

The dependent variable of the study was ‘extent of farm waste utilization’ and was measured on a four-point response scale. Respondents were required to indicate how many of the identified farm wastes they make use or have ever made use of for the purpose indicated as compiled during preliminary survey and from literature. Each of the waste identified by the respondent was scored 1 point each. Then, on a 4 point response scale, they were required to indicate the extent of their utilization of these farm wastes, and were scored as follows: never utilized (0 point), rarely utilized (1 point), sometime utilized (2 points), and always utilized (3 points). Key independent variables are measured as follows: attitude towards utilization of farm waste was measured by requesting respondents to respond to some 20 statements using a 5 point Likert scale. The responses strongly agreed, agreed, undecided were scored 5, 4 and 3 points respectively, while disagree and strongly disagree were scored 2 and 1, respectively.

Perceived Behavioral Control (PBC) refers to respondents’ confidence in their ability to utilize farm waste and perception of how easy or difficult it is to do this (i.e. utilize these farm wastes). It was measured on a 5 point scale. They were requested to react to some statements and their responses were scored as follows: Extremely difficult (5 points), somewhat difficult (4 points), Not sure (3 point points), somewhat easy (2 points), and extremely easy (1 point).Subjective norm seeks to measure how likely or otherwise, the concern or consideration for other people (like relatives, friends, etc) might influence farm waste utilization behavior of respondents, they were requested to respond to statements on a 5 point scale with the following options: Extremely likely (5 points), most likely (4 points), not sure (3 points), most unlikely (2 points), and extremely unlikely (1).Perception about farm waste items’ economic potentials: respondents were asked to indicate their perception about the usefulness (i.e. potential for utilization) of each of the identified items listed as farm wastes. The options were scored thus: 5 very valuable, 4 somewhat valuable, 3 not sure, 2 somewhat worthless, 1 very worthless.

Both content and construct validity techniques were employed to validate the research instrument. For content validity, academic experts with specialization in Rural Development were requested to critically examine and review the research instrument in relation to the objectives of the study. Suggestions and recommendations given were employed in restructuring of the research instrument prior to field survey. For construct validity, the instrument was considered alongside key variables derived from both theories on which the study was based to ensure that conformity. Furthermore, test-retest reliability was carried out on the research instrument to determine the degree of consistency to which it measures the variables it was designed to measure. The interview schedule was administered on ten individuals in two communities from Ife-East and Atakumosa East Local Government Areas, which were not included amongst Local Government Areas sampled for the study. At two weeks interval, it was re-administered on these same set of respondents. The two test scores were correlated using Spearman's Ranked Order Correlation (SROC) analysis. With correlation coefficient (r = 0.80) obtained from the analysis, the research instrument was adjudged reliable since the correlation value of 0.7 and above are considered as satisfactory or good for a test-retest reliability.

V. RESULTS AND DISCUSSION

5.1 Socio-demographic attributes of respondents

Results in Table 1 show that about half (50.8 %) of the respondents were male while 49.2 per cent were female. The results indicated that almost equal proportion of male and female respondents were sampled for the study. This implied that the study equally focused on both male and female those are major components of rural farm family and extension clientele; therefore gender implications of farm waste utilization for enhancing rural dwellers' livelihood would be documented.

TABLE 1
DISTRIBUTION OF RESPONDENTS BY SOCIO-DEMOGRAPHIC CHARACTERISTICS

Variable	Frequency	Percentage(n = 364)	
Sex			
Male	185	50.8	
Female	179	49.2	
Age (Years)			
20 – 34	41	11.3	
35 – 49	108	29.7	Mean = 52.73
50 – 64	104	28.6	SD = 14.74
65 – 79	86	23.6	
80 and above	25	6.8	
Years of formal education			
Below 6	140	38.5	
7 – 12	114	31.3	Mean = 7.24
Above 12	25	6.9	SD = 4.83
Had no formal education	85	23.4	
Level of educational attainment			
Koranic education	15	4.1	
Adult education	32	8.8	
Primary school incomplete	25	6.9	
Primary school completed	112	30.8	
Secondary school incomplete	46	12.6	
Secondary school completed	42	11.5	
Tertiary education completed	7	1.9	
Not applicable	85	23.4	
***Major occupation**			
Farming	296	81.3	
Agro-processing	124	34.1	
Petty trading	108	29.7	
Livestock rearing	85	23.4	
Hunting	57	15.7	
***Minor occupation**			
Farming	36	9.9	
Agro-processing	39	10.7	
Petty trading	32	8.8	
Livestock rearing	49	13.5	
Hunting	6	1.6	

Multiple response possible
SD = Standard deviation

About 30 per cent and 29 per cent of the respondents were aged between 35 – 49 years and 50 – 64 years, respectively. While, 23.6 per cent were within 65 – 79 years age range, few (11.3 %) were within 20 – 34 years range, and very few (6.8 %) were aged above 80 years. Mean age of respondent was 52.73 years with a standard deviation of 14.74. These results indicated that the respondents were vibrant and within their productive age range. The findings which agreed with Jibowo's

(2003) assertion that the rural areas in most countries have higher proportion of its population aged above 45 years, implied that respondents could still actively engage in waste utilization and should be encouraged to derive economic benefit from waste items emanating from their daily livelihood pursuits in order to improving their standard of living.

About 30.8 per cent and 11.5 per cent of the respondents completed primary and senior secondary education, respectively, while very few (1.9 %) completed tertiary education. About 8 per cent and 4 per cent had only adult education and Quranic education, respectively. Also, while 38.5 per cent spent up to 6 years to obtain formal education, 31.3 per cent spent between 7 and 12 years. Average number of year spent by respondent on attaining formal education was about 7 years with a standard deviation of 4.8. In addition, 65.4 per cent of the respondents indicated they could read and write, implying their literacy in English Language. The findings aligned with the submissions of Soyebo (2005) and Alao (2010) that rural dwellers in the study area were literate. The implication of this submission is that respondents are likely to be more receptive of innovations and improved practices and new ideas introduced to them.

Majority (81.3 %) of the respondents engaged in farming as major occupation. While 34.1 per cent and 29.7 per cent engaged in agro-processing and petty trading as major occupation; 23.4 per cent and 15.7 per cent primarily engaged in livestock rearing and hunting, respectively. Also, few proportions amongst the respondents engaged in these various occupational activities as minor means of livelihood. The results, which concurred with the findings of Yusuf (2011), indicated that rural dwellers engaged in a variety of activities as occupation with agriculture usually the prime. They engaged in these varieties of activities including non-farm in order to make ends meet and spread their risks better. The implication of the findings is that rural inhabitants are multi-tasked people and are likely to engage in supplementary activities that will fetch them additional income. This situation may be explored and exploited through sensitizing rural dwellers and drawing their attention to potentials and opportunities that abound in utilization of farm waste items available within the rural environment as useful resources. Extension has a great role to play in the promotion of acknowledging various farm waste items as part of natural assets base which rural dwellers can benefit from.

Majority (88.5 %) and 84.1 per cent of the respondents cultivated cassava and maize crops, respectively, using 2.65 and 1.87 acres of land. Also, 72 per cent, 64.6 per cent, 62 per cent and 59.1 per cent cultivated yam, vegetable, cowpea and cocoyam, respectively, on 3.4, 1.49, 1.75 and 1.77 acres of land. Few (18.7 % and 19.5 %) cultivated soybean and rice, using 1.8 and 1.7 acres of land, while 51 per cent cultivated sweet potatoes on 0.5 acres of land. The results indicated that respondents cultivated a variety of arable crops, amongst which cassava and maize were most prominent, followed by vegetable, yam and cocoyam. The implication of the findings is that farm waste items generated from these crops after harvest, such as cassava peels, maize husk, cob, and shaft, cocoyam corm, cowpea and soybean husk and vine, etc, which have economic potentials for utilization that may be judiciously put to use by the rural dwellers were available in the study area.

Results in that 71.2 per cent and 67 per cent of the respondents cultivated oil palm and cocoa, on 4.97 and 8.5 acres of land, respectively. Furthermore, 52.7 per cent and 53 per cent cultivated citrus and banana/plantain crops, using 2.23 and 1.8 acres of land, while 39 per cent cultivated cashew crop on 2.82 acres of land. Others (48 % and 43 %) cultivated coconut and kola nut on 1.5 acres and 0.8 acres of land, respectively. The results indicated that respondents cultivated a variety of field crops amongst which oil palm and cocoa were prominent. The implication of the findings is that farm waste items generated from these crops after harvest or during processing such as palm kernel shell, empty palm fruit bunch, cocoa pods, etc, which have economic potentials for utilization are available in the study area that could be harnessed for economic empowerment of the rural inhabitants.

More than half (58.5 %) of the respondents raised poultry birds. Also, 28.8 per cent, 50 per cent and 22.5 per cent reared sheep, goat and cattle, respectively, while about 21 per cent each reared fish and rabbit. Average number of poultry bird raised was 12, while average number of sheep, goat and cow reared was 6, 8 and 4 respectively. Furthermore, about 25 per cent of the respondents are involved in piggery with average number of pig as 12. The results indicated that respondents engaged in rearing of livestock too, apart from crop cultivation, and poultry birds and goats were most prominent amongst these livestock. However, scale of production of livestock was low.

It may be inferred from the findings that farm waste items generated from rearing of livestock such as poultry droppings, goat and sheep faeces, and cow dung which have economic potentials for utilization might, although available within the study area, might be inadequate for utilization. The implication of the findings is that respondents may be encouraged to increase their scale of livestock production and with adequate training opportunities they may be empowered on various ways of converting the livestock wastes into useful resources that can generate wealth and translate to additional income for them.

Results show that, on an annual basis, 39 per cent of the respondent earned below ₦ 200, 000 while 15.1 per cent and 16.2 per cent earned between ₦ 200,000 and ₦ 400,000 and ₦ 400,000 and ₦ 600,000, respectively. Mean annual income was ₦ 382,500. This value represents annual income of respondents from crop cultivation (arable and permanent crops), livestock rearing and agro-processing pulled together which translated to ₦31,875 monthly. This is still a meagre amount considering the degree of drudgery involved in the various activities rural inhabitants go through before earning this amount. In fact, findings during field survey further reveal that, most times, respondents' earnings were used to settle debts often incurred beforehand as soon as earning them. The implication of the findings is that rural inhabitants could be empowered economically through judicious use of farm waste items available at their disposal, through which they could increase their earnings and be better enabled to meet their financial obligations.

5.2 Results of regression analysis

Results in Table 2 show that total herd size (t = 2.711), income (t = 2.401), perception about farm waste items (t = 4.458), perceived behavioral control (t = 2.534) and attitude towards farm waste utilization (t = 2.732) positively and significantly contributed to extent of farm waste utilization at $p \leq 0.01$. Also, total farm size (t = 1.988) and years spent on formal education (t = 2.024) positively and significantly contributed to extent of farm waste utilization at $p \leq 0.05$. However, information source (t = -2.732) while knowledge about farm waste utilization potentials (t = -2.314) also significantly but negatively influenced farm waste utilization at $p \leq 0.05$.

TABLE 2
RESULTS OF MULTIPLE REGRESSION ANALYSIS ESTABLISHING RELATIONSHIP BETWEEN SELECTED VARIABLES AND FARM WASTE UTILIZATION

Variable	Standardized coefficient Beta	t	p - value
Age	-0.042	-0.556	0.580
Household size	-0.006	-0.009	0.992
Residency length	0.072	0.974	0.332
Total farm size	0.267	1.988*	0.049
Total herd size	0.278	2.711**	0.008
Years of formal education	0.139	2.024*	0.045
Income	0.309	2.401**	0.018
Information source	-0.256	-2.732**	0.007
Rivalry/dispute	-0.435	-4.837*	0.000
Subjective norm	0.013	0.183	0.855
PBC	0.343	2.534**	0.013
Attitude towards farm waste Utilization	0.395	2.732**	0.007
Knowledge about farm waste Utilization potentials	-0.497	-2.314*	0.022
Perception about farm waste	0.789	4.458**	0.000

Of the three key variables of TPB, result revealed that perceived behavioral control and attitude towards farm waste utilization were positive and significant determinants of farm waste utilization. Subjective norm did not have significant influence on farm waste utilization. The findings agreed with the submission of Ho (2002) and Tonglet *et al.* (2004) that identified perceived behavioral control and attitude as important determinant of utilization behavior. The results indicated that the more knowledge an individual possess about the utilization potential of a particular farm waste item and the more favorably they perceive the farm waste item, the higher the likelihood that they utilized such farm waste items. The implication of these findings is that strengthening rural dwellers' PBC and influencing their perception about farm waste items could enhance their resolve to judiciously exploit the economic potentials of these farm waste items to enhance their livelihood. Here, extension agents and rural development agencies have a paramount role to play. The non-significance of subjective norm with farm waste utilization could imply that consideration for other people's opinion was not considered enough to discourage an individual from farm waste utilization, perhaps, so long as economic return there from is guaranteed. This is similar to the findings of Niaura (2013) whose study revealed that subjective norm had less impact on youth behavioral intentions when compared to perceived behavioral control.

Plausible explanation for negative contribution of 'knowledge about farm waste utilization potential' to the regression model is necessary. The result apparently indicates that the lesser the knowledge respondents possess about utilization potentials of various farm waste items; the more they utilized such farm waste items. Conceivable explanation is that respondents tend to utilize more of few farm wastes they know about, since reasonably, they may not be able to effectively and efficiently utilize all these farm waste items at a time. The implication is that extension agents and agencies should make concerted efforts to concentrate on fewer farm waste items with economic potentials in order to empower rural dwellers.

The overall regression model summary show that R^2 value of 0.575 was obtained in the analysis. Also F value of 11.002 obtained was significant at $p \leq 0.01$. This indicated 57.5 per cent variation in the dependent variable was accounted for by the independent variables included in the regression analysis. The remaining 42.5 per cent was due to other variables not included in the analysis.

VI. ATTAINMENT OF SUSTAINABLE LIVELIHOODS AND ECONOMIC EMPOWERMENT OF RURAL DWELLERS: WHITHER FARM WASTE UTILIZATION?

The bane of research problem of this study was that rural dwellers have conventionally limited their quest for livelihood to production of certain crops, raising of few livestock, and engaging in non-farm activities, such as petty trading and agro-processing. While this is a form of livelihood diversification, the full potentials of several waste items emanating from their livelihood choices have not been well harnessed to their advantage. This study emphasized the need for recognition of farm waste items emanating from various livelihood pursuits of the rural dwellers as part of the natural assets which should be judiciously harnessed and utilized as important local resources.

The study's findings also stressed the need for intensification, whereby rural inhabitants increase their scale of production, livestock production, for example; using intensive management system. This will ensure both increase in availability of waste items, like poultry droppings and sheep and goat faeces for use as manure and fish feed, respectively, and also facilitate their easy collection. While recognizing the high cost associated with livestock feeding, the study encouraged judicious utilization of farm wastes (such as maize stalk, cowpea husk, rice husk and bran, maize cob, etc.) as livestock feed. Also, growing of maggots on waste such as poultry droppings, blood of slaughtered animals, etc. could be useful supplement to costly fish feeds. So it is like a cycle: crop residues used as feed for livestock, and animal wastes in turn converted into manure for crop's use.

These submissions, therefore, emphasize 'reuse' and 'recycling' of farm waste items, which represent two of the 3 r's that are important in waste management. The third is 'reduce', that is, to reduce waste generation as much as possible. However, this study would not subscribe to that. Rather, it canvasses for generation of more farm waste as earlier asserted which should be shrewdly harnessed as important local resources. The reason is because the 3 r's are proposed in solid waste management where wastes include non-biodegradable items. On the other hand, farm waste items are biodegradable and where they are not utilized, they readily decompose. So in a typical farm-family farm, it is the submission of this study that such cycle for recycling and reuse of farm waste be encouraged and practiced. This will help to help rural dwellers to spread their risks better, thereby better assured of sustainable rural livelihoods.

It is also the submission of this study that there are several enterprises which primarily depend on utilization of farm waste items through which the rural inhabitants can be economically empowered. Although, these enterprises are not entirely new, however, there is need for revitalization, intensification and introduction of value addition to make the final products more acceptable and more economically rewarding for the rural people. Such enterprise include mushroom production, dye production, intensification in livestock production, black soap production, fish feed production, maggot culturing, bone meal production, intensive broom production, snailery production and organic manure production. These are areas rural dwellers may be economically empowered, and extension, government and university outreach have roles to play. The roles include continuous creation awareness about the utilization potentials of various farm waste items and organization of capacity building and training workshops for rural dwellers in Osun state in order to improve their knowledge level and skills which will better equip them for effective utilization of farm waste items.

VII. CONCLUSION AND RECOMMENDATION

In conclusion, there were several farm waste items that have economic potentials for utilization in the study area. The author's emphasized consideration of these waste items as part of the natural asset base within the rural environment, which if utilized by rural dwellers as important local resources can engender sustainable livelihood diversification and economic empowerment of the rural populace. By way of recommendation, the state Agricultural Development agency, Non-

Governmental Organizations (NGOs), Community Based Organizations (CBOs) and media outfit should explore and exploit the multitask ability of the rural inhabitants through sensitizing them and drawing their attention to vast potentials and opportunities that abound in utilization of farm waste items available within the rural environment as useful local resources.

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Application of bioflocculant-producing bacteria, heterotrophic nitrogen-removal bacteria, poly-phosphate bacteria and water-hyacinth (*Eichhornia crassipes*) for wastewater treatment of My Tho rice-noodle factories, Tien Giang province, Vietnam

Le Thi Loan[1*], Tran Vu Phuong[2], Cao Ngoc Diep[3]

[1]Dept. Educational high school, Dept. Education - Training, Tien Giang province, Vietnam
*corresponding author
[2]Department of Microbiology Biotechnology, Can Tho University, VIET NAM
[3]Department of Microbiology Biotechnology, Can Tho University, VIET NAM

Abstract— *Rice-noodle wastewater represents a serious problem regarding environmental degradation and human health protection. The aim of the study was to create the application of bioflocculant-producing bacteria, heterotrophic nitrogen-removal bacteria, poly-phosphate bacteria and water hyacinth (Eichhornia crassipes) for wastewater treatment of My Tho rice noodle factories, Tien Giang province, Vietnam in order to get an insight into number of entities that discharge polluted water into environment. An experiment was carried out with containers having different capacities from 100-mL, 1-L, 10-L, 100-L and 1000-L and 3 replications to select best strains of bioflocculant-producing bacteria, heterotrophic nitrogen bacteria, poly-P bacteria and water-hyacinth for removing toxic element to wastewater before releasing to river/canal. Application of two bioflocculant-producing bacterial strains PO.01.C and PRO.03.B (protein and polysaccharide) into rice-noodle wastewater, aeration in 3 hours, held on 21 hours, supernatant moved to other container, adding heterotrophic nitrogen removal bacterial strain and poly-P. strain 064.B, aeration 8 hr/24hr during 7 days and wastewaters were transferred other containers containing water-hyacinth (Eichhornia crassipes) in 2 days, the results recorded that pH of wastewater increased from 4.68 to 6.13, TSS and BOD_5 concentration of wastewater reduced from 369 and 1200 mg/L to 17 and 23 mg/L, respectively. TKN and TP decreased from 45 and 6.3 mg/L to 7.57 and 4.56 mg/L, respectively. All targets reached to 40/2011 standard / Ministry of Natural Resource and Environment of Viet nam.*

Keywords - Bioflocculant-producing bacteria, Heterotrophic Nitrogen Removal Bacteria, Poly-Phosphate bacteria, Rice-noodle, wastewater, water-hyacinth.

I. INTRODUCTION

Rice noodles are the most consumed form of rice product next to cooked rice grain in Asia [1]. Noodles may either be served by frying and mixing with vegetables and meats or served as a soup noodle by boiling in a broth. Rice protein lack gluten; hence lack the functionality of continuous visco-elastic dough.

My Tho city, a city locates in the Mekong Delta, Vietnam, has many traditional technologies and “My Tho rice noodle” is among famous technology for a long time. Rice noodle has been produced from special local rice variety and there are seven manufacture factories have gathered in a cooperative and they have a “HU TIEU MY THO” trademark. However these factories work in the traditional condition therefore they have no wastewater treatment plant and wastewater have irrigated to canal or river directly. Especially wastewater from rice noodle factories contain many toxic elements as ammonium, orthophosphate,… and high TN, TP, BOD_5, TSS concentrations [2].

Wastewater generated from these industries depicts wide variation in strength and characteristics. Variation due to the amount of water usage, type of vegetable and fruits used type of product and different additives like salt, sugar, gelatin, colors, oil and preservatives added also leads to the pollution load in the wastewater but this wastewater is non toxic in nature because it comprises less hazardous compounds. Almost 50% of the water utilized in food processing industry is for washing and rinsing purposes. Water being the primary ingredient is widely used as a cleaning agent in food processing industry [3].

After cellulose, starch is the second polysaccharide found in nature, produced by plants as reserve material. The main cultivated actually plants for the starch industrially production are cereals, especially corn, followed by wheat and potato [4].

Generally, rice noodles are made from flour containing high amylose concentration (> 22%), which contributes to the gel network. It provides firm structure and desirable properties to noodle [1,5]. There is significant association found between amylose and acceptability of rice noodles [6].

Physicochemical wastewater treatment is a frequently used technique in the area of wastewater treatment [3]. Physicochemical wastewater treatment techniques are applied for the removal of heavy metals, oils and greases, suspended matter and emulgating organic substances, organic and inorganic components, difficult to decompose, non polar organic substances, toxic pollutants or high salt concentrations, phosphorus [7].

Under food processing industry, Palm oil refining wastewater has been successfully treated by physicochemical treatment using chitosan, alum and PAC and reported [8].

Flocculants are divided into inorganic flocculants such as aluminium sulfate (Alum) and polyaluminium chloride (PAC), organic synthetic high polymer flocculants such as polyacrylamide (PAA) derivatives, polyacrylic acids and polyethylene imine and naturally occurring bio-polymers flocculants such as chitosan, sodium alginate and microbial flocculants or bioflocculant [9,10,11]. Bioflocculant is a kind of biodegradable macromolecular flocculant secreted by microorganisms. Because of their biodegradability, harmlessness and lack of secondary pollution, bioflocculants have gained much wider attention and research to date [12]. Most of research focused on screening for microorganisms, culture conditions, mechanism of flocculation, chemical structure, and so on [13,14,15,16,17].

The aims of this study were (i) applying bioflocculant-producing bacteria to reduce organic and inorganic components, (total suspended solids = TSS) (ii) using heteroytophic nitrogen removal bacteria and poly-phosphate bacteria to decrease total kjeldahl nitrogen (TKN) and Total phosphorus (TP) and (iii) application of water hyacinth to remove or reduce (Bio-Oxygen Demand) BOD_5 concentration in wastewater reaching to 40:2011 standard of Ministry of Natural Resources and Environment Vietnam.

II. MATERIALS AND METHODS

2.1 Materials

Wastewater from rice-noodle factories at My Tho city, Tien Giang province with characteristics as follows (Table 1)

TABLE 1
pH AND PHYSICAL AND CHEMICAL CHARACTERISTICS OF WASTEWATER FROM RICE NOODLE FACTORIES OF MY THO CITY, TIEN GIANG PROVINCE, VIETNAM$^+$

Treatment	1-L and 10-L Experiments	100-L Exp.	1000-L Exp.	40/2011 Standard*
pH	4.13	3.84	4.68	5.5 – 9.0
Total kjeldahl nitrogen (TKN) (mg/L)	99.82	26.71	45,11	40
Total phosphorus (TP) (mg/L)	2.64	5.43	6.31	6
Total of Suspended solids (TSS) (mg/L)	4544	620	369	100
Biochemical Oxygen Demand (BOD_5) (mg/L)	6160	950	1200	50
Total Ammonium (TAN) (mg/L)	4.55	7.12	6.31	10

$^+$ ***data from Centre for Teqnique and Biotechnology, Tien Giang Science and Technology, Department.***
****Ministry of Natural Resource and Environment***

2.1.1 Environmental bacteria:

- Bioflocculant-producing bacteria: six strains as *Bacillus subtilis* PRO.01C, *Bacillus subtilis* PRO.03B, *B. tequilensis* PRO.07.04, *B. megaterium* PRO.04.01, *B. tequilensis* PO.08A and *Bacillus subtilis* PO.03.05 [2] were grown in culture media [18] (Deng *et al*.,) and [19], Hazana *et al*. separately.
- Heterotrophic nitrogen-removal bacteria: as four strains: *Bacillus altitudinis* HNi03DL, *Stenotrophomonas maltophilia* HNa03C, *Enterobacter hormaechei* HAm05C, *Achromobacter xylosoxidans* HNa07B were grown in nitrogen medium [20] and poly-phosphate bacteria: *Bacillus megaterium* POLY.P. 064B was grown in poly-P medium [21], the heterotrophic nitrogen removal and poly-P bacterial strains were selected from previous experiments [2].

All of strains were contained in suitable containers as flasks 500-L or 2000-mL on rotary with 120 rpm in 24 h or 72 h, until they reached to >10^9 CFU/ml and they were used as inoculation in all experiments.

2.2 Methods

Wastewater were used in these experiments from Mr. Truong Van Thuan's rice noodle factory (in all experiments from 1-L, 10-L, 100-L and 1000-L) and pH, physical together with chemical in these experiments were presented in Table 1

2.2.1 Experiment layout

Wastewater was filtered through filterable equipment to deplete material having big size (>1 mm) out of wastewater.

2.2.1.1 Bioflocculant-producing bacteria

The aim of this experiment was selection of bacterial strain having high flocculation

2.2.1.2 Experiment 100-mL, 1-L and 10-L

A. Experiment 100-mL:

The experiment was completely randomized design with three replications, the treatment composed of control (without bacteria) and the bioflocculant-producing (protein and/or polysaccharide) bacterial strains (*Bacillus subtilis* PRO.01C, *Bacillus subtilis* PO.01C, *B. tequilensis* PRO.07.04, *B. megaterium* PRO.04.01, *B. tequilensis* PO.08A and *Bacillus subtilis* PO.03.05).

Wastewater were distributed in the flask-250 mL containing 100 ml wastewater, inoculated 0.1 ml bacterial inoculation, adjusted pH=7; put the flasks on the rotary, 60 rpm in 60 sec, after that these flasks were hold on in 1 hour, supernants of each flask were measured flocculating activity. The good bioflocculant-producing (protein or/and polysaccharide) bacterial strains were selected for the next experiment.

B. Experiment 1-L:

The experiment was completely randomized design with three replications, the treatment composed of control (without bacteria) and bioflocculant-producing (protein or/and polysaccharide) bacterial strains

Wastewater were distributed in the flask-2000 mL containing 1000 ml wastewater, inoculated 1 ml bacterial inoculation, adjusted pH=7; put the flasks on the rotary, 60 rpm in 60 sec, after that these flasks were hold on in 1 hour, supernants of each flask were measured flocculating activity. The good bioflocculant-producing (protein or/and polysaccharide) bacterial strains were selected for the next experiment.

C. Experiment 10-L:

The experiment was completely randomized design with three replications, the treatment composed of control (without bacteria) and bioflocculant-producing (protein or/and polysaccharide) bacterial strains.

Wastewater were distributed in the container 20-Litre containing 10 liters wastewater, inoculated 10 ml bacterial inoculation, adjusted pH=7; put the flasks on the rotary, 60 rpm in 60 sec, after that these flasks were hold on in 1 hour, supernants of each flask were measured flocculating activity. The good bioflocculant-producing (protein or/and polysaccharide) bacterial strains were selected for the 100-L and 1000-L experiments.

2.2.1.3 Heterotrophic nitrogen removal bacteria and poly-P bacteria

The aim of this experiment was selecting of best heterotrophic nitrogen removal bacterial strains

A. Experiment 1-L:

The experiment was completely randomized design with three replications, the treatment composed of control (without bacteria) and heterotrophic nitrogen removal bacterial strains as *Bacillus altitudinis* HNi03DL, *Stenotrophomonas maltophilia* HNa03C, *Enterobacter hormaechei* HAm05C, *Achromobacter xylosoxidans* HNa07B [2]. The experiment was done in 3 days, aeration.

In the poly-P bacteria, the experiment composed of control and *Bacillus megaterium* POLY.P. 064B, with and without aeration, it was done 3 days with three replications.

Ammonium and Orthophosphate were measured by color metric method.

B. Experiment 100-L:

The experiment was completely randomized design with three replications, each treatment was a container 120-litre containing 100 liters wastewater. The experiment divided two stages:

- wastewater treated with bioflocculant-producing bacteria (as described above)
- supernatant treated with heterotrophic nitrogen removal bacteria and poly-P bacteria

Wastewater added with selected bioflocculant-producing bacteria from experiment 10-L of bioflocculant-producing bacteria, inoculated 100 ml bacterial inoculation, adjusted pH=7; aeration by air-pump in 1 hour, after that these containers were hold on in 3 hours, supernatants of each container were transferred to another container, added 50 ml selected heterotrophic nitrogen removal bacteria and 50 ml poly-P bacteria strains from result of experiment 1-L heterotrophic nitrogen removal bacteria and poly-P bacteria, aeration 8/24 h during 4 days (see flowchart) (Figure 1).

C. Experiment 1000-L

The experiment was the same as the experiment 1000-L but container 1200-litre containing 1000 litres wastewater, aeration in 3 hours and held on 21 hours, supernatants of each container were transferred to another container, added 500 ml selected heterotrophic nitrogen removal bacteria and 500 ml poly-P bacteria strains from result of experiment 1-L heterotrophic nitrogen removal bacteria and poly-P bacteria, aeration 8/24 h (two times per day, 4 hours in the morning and 4 hours in the afternoon) during 7 days and wastewaters were transferred other containers containing water-hyacinth (*Eichhornia crassipes*) in 2 days and water samples were collected to measured ammonium, orthophosphate, TKN, TP, TSS, BOD_5 and pH (see flowchart).

2.2.2 Analytical methods

Flocculation was determined by measuring the absorbance of the upper phase of suspension at 550 nm. A control experiment using 0.5 ml of distilled water was used instead of the cultures broth was added to the suspension performed in the same manner and the absorbance was measured. Determination of the flocculating activity and flocculation rate was determined using following formula [19].

$$\text{Flocculating activity} = (1/A - 1/B) \quad (1)$$

$$\text{Flocculation rate (\%)} = B - A \times 100/B \quad (2)$$

A = absorbance of the samples

B = absorbance of the control

NH_4^+-N (Colometric method or Phenol nitroprusside method) [22], BOD_5, Orthophosphate (Colormetric method), TP, TKN and pH (pH meter) were determined by Advanced Analyses Laboratory, Can Tho University, Viet Nam.

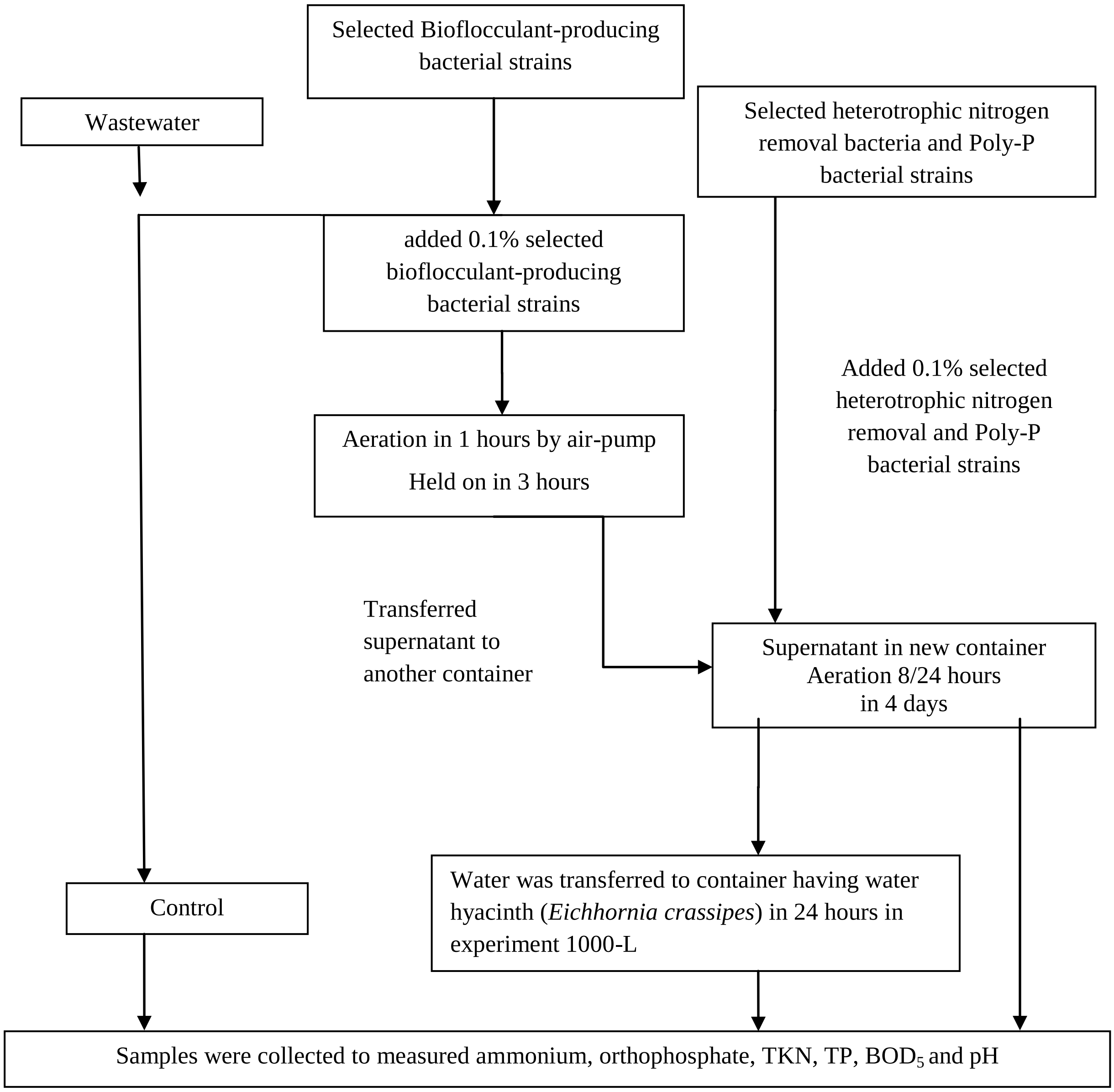

FIGURE 1. Flowchart presented the process of application bacteria and water-hyacinth for rice noodle wastewater treatment

2.2.3 Statistical Analysis

The experiment was analyzed as a two-way ANOVA with the isolates and with levels of flocculating rate (%), N as ammonium, P as orthophosphate. All analyses were conducted using the programme MSTATC, Minitab 16. The data were considered significantly different at $P<0.01$.

III. RESULTS AND DISCUSSION

3.1 Bioflocculant-producing bacteria

3.1.1 100-mL experiment, 1-L and 10-L experiments

The result from figure 2 showed that strains as PRO.07.04, PRO.01.C and PRO.03.B were the best polysaccaride-producing bacterial strains, and PO.01.C was the best protein-producing bacterial strain in comparison to 2 other strains. Combination of two strains [PRO.03.B + PO.01.C] had the highest flocculant rate (%) in comparison to two other combinations (Figure 3).

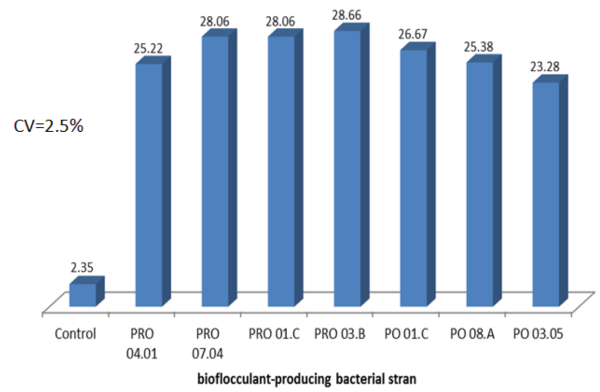

FIGURE 2. Ability of flocculant activity of 7 bioflocculant-producing bacterial strains in rice noodle wastewater

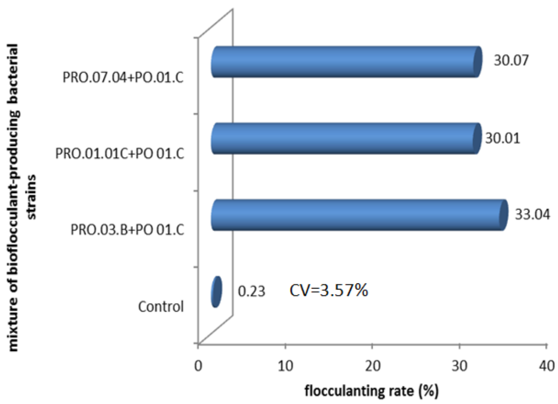

FIGURE 3. Ability of flocculant activity of combination of 2 bioflocculant-producing bacterial strains in rice-noodle wastewater

This combination [PRO.03.B + PO.01.C] applied in wastewater in 1-L and 10-L containers gave good results (Figure 4).

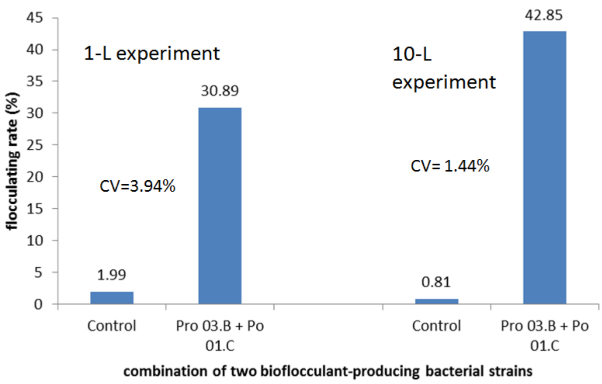

FIGURE 4. Ability of two flocculant- producing bacterial strains PRO.03.B + PO.01.C in the rice-noodle wastewater

The mixture of two strains [PRO.03.B + PO.01.C] was used in the next experiment.

3.2 Heterotrophic nitrogen removal bacteria and poly-P bacteria

3.2.1 Experiment 1-L:

The results from Figure 5 and Figure 6 showed that HNa03C strain reduced ammonium and orthophosphate concentrations in rice-noodle wastewater better than other strains after 3 days aeration continuously.

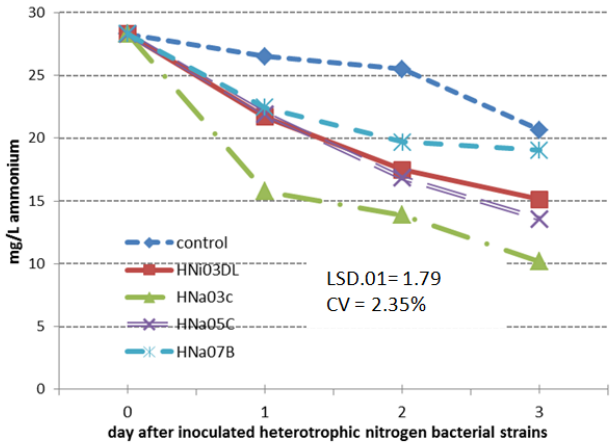

FIGURE 5. Effects of heterotrophic nitrogen on ammonium concentration (mg/L) in rice-noodle wastewater in 1-L experiment

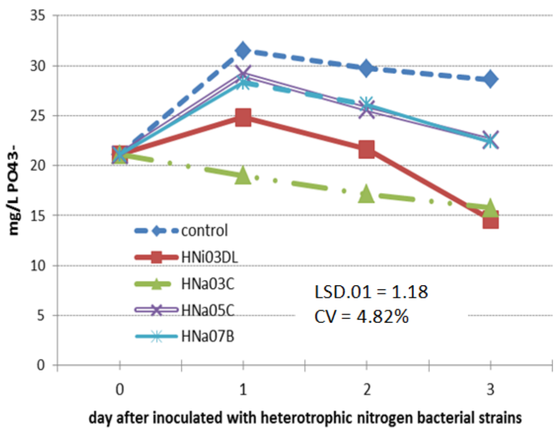

FIGURE 6. Effects of heterotrophic nitrogen on orthophosphate concentration (mg/L) in rice-noodle wastewater in 1-L experiment

In aeration condition, poly-P 064.B strain reduced ammonium and orthophosphate concentrations in rice-noodle wastewater clearly in comparison to without aeration and control (without bacteria) (Figure 7 and Figure 8).

Therefore, two strains, HNa03C and poly-P 064.B were chosen to use to next experiment.

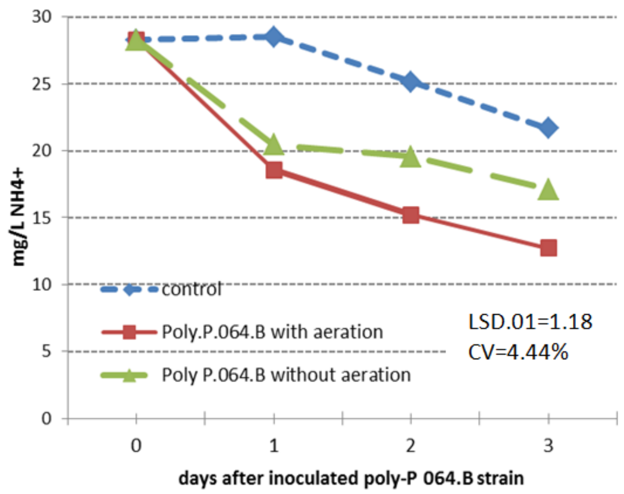

FIGURE 7. Effects of poly-P bacteria on ammonium concentration (mg/L) in rice-noodle wastewater

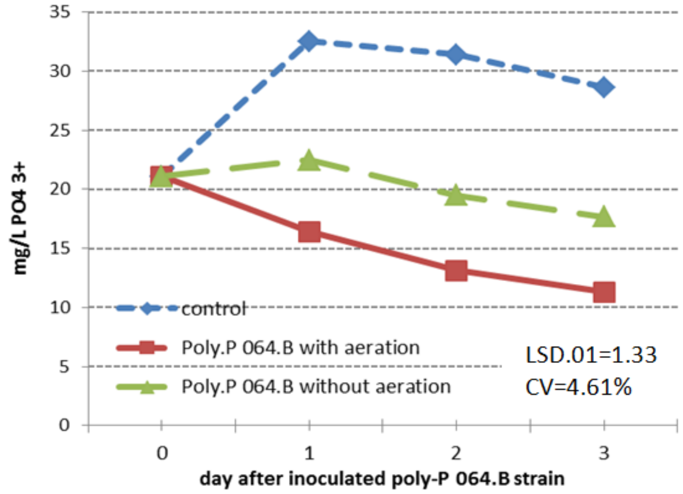

FIGURE 8. Effects of poly-P bacteria on orthophosphate concentration (mg/L) in rice-noodle wastewater

3.2.2 Experiment 100-L:

The result from Table 2 showed that pH of wastewater at initial stage was 3.84 and in control treatment (without bacteria) pH of wastewater increased to 4.61 but adding bioflocculant-producing bacteria and heterotrophic nitrogen removal, poly-P bacteria into wastewater supported pH of wastewater. Total of Suspended Solids (TSS) and Biochemical Oxygen Demand (BOD_5) in wastewater were very high (620 and 950 mg/L, respectively) and TSS and BOD_5 concentration wastewater reduced strongly after 4 days especially in bacterial application treatment, BOD_5 concentration wastewater decreased down one third (in comparison to initial stage). Total Kjeldahl Nitorgen (TKN) in wastewater decreased but total phosphorus (TP) in wastewater increased.

TABLE 2
EFFECTS OF BIOFLOCCULANT-PRODUCING BACTERIA AND HETEROTROPHIC NITROGEN REMOVAL, POLY-P BACTERIA ON PH AND PHYSICAL AND CHEMICAL OF RICE-NOODLE WASTEWATER

Treatment	Initial	control	Bacterial application*	Effectiveness (%) compared to initial
pH	3.84	4.61	6.02	30.56
Total of Suspended Sodids (TSS) mg/L	620	58	55	510.00
Biological Oxygen Demand (BOD_5) mg/L	950	450	300	216.66
Total Kjeldahl Nitrogen (TKN) mg/L	26.7	11.1	10.5	154.26
Total Phosphorus (TP) mg/L	5.4	6.2	17.6	-

bioflocculant-producing bacteria and heterotrophic nitrogen removal, poly-P bacteria

3.2.3 Experiment 1000-L

pH of wastewater in bacteria treatment increased strongly through bioflocculant-producing bacteria stage and heterotrophic nitrogen removal, poly-P bacteria stage from 4.89 to 6.98, after that pH of wastewater reduced slowly (to 6.13) while pH wastewater in control treatment also increased to 5.71 (Figure 9). BOD_5 concentration of wastewater in bacteria treatment reduced strongly in two stages (bioflocculant-producing bacteria and nitrogen removal & poly-P bacteria) (more than 2.4 times compared to initial), in water-hyacinth stage, after that BOD_5 concentration of wastewater almost did not change. In control treatment, BOD_5 concentration only reduced in nitrogen removal and poly-P bacteria stage (Figure 10). The same as BOD_5 case, TSS concentration of wastewater also only reduced strongly in bacteria stage (more than 23.6 times compared to initial).

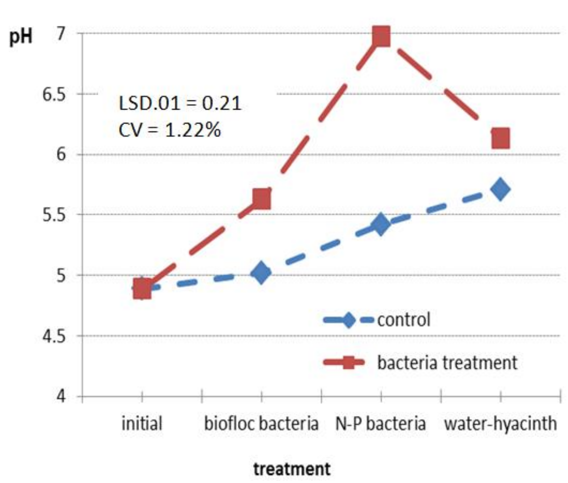

FIGURE 9. Effects of bacteria and water hyacinth on pH of rice-noodle wastewater

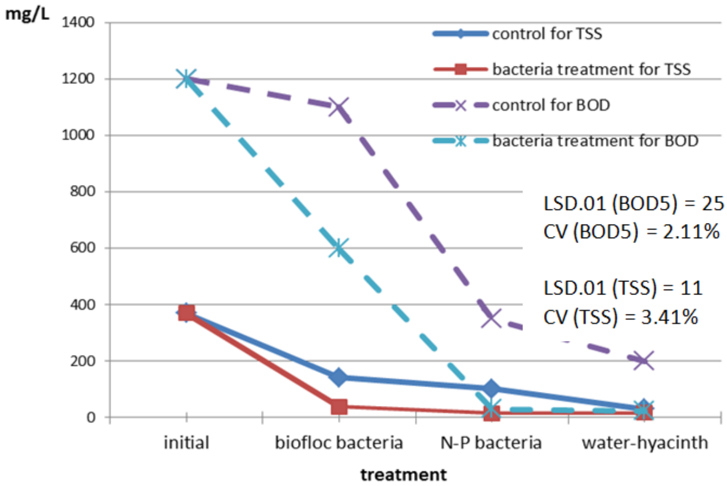

FIGURE 10. Effects of bacteria and water hyacinth on TSS and BOD_5 of rice-noodle wastewater

Application of bacteria in rice-noodle wastewater, TKN concentration of wastewater reduced during 3 stages while TKN concentration of wastewater in control treatment increased in all stages (from 45 mg/L decreased to 7.57 mg/L (reduced 49.44%). Applying bioflocculant-producing bacteria decreased TP concentration of wastewater but adding heterotrophic nitrogen removal, poly-P bacteria increased TP concentration and TP concentration only reduced when wastewater moved into container containing water-hyacinth (in 2 days). On the contrary, TP concentration on wastewater of control treatment only enhanced during 3 stages (from 6.3 decreased to 4.76 mg/L, reduced 32.35%) (Figure 11).

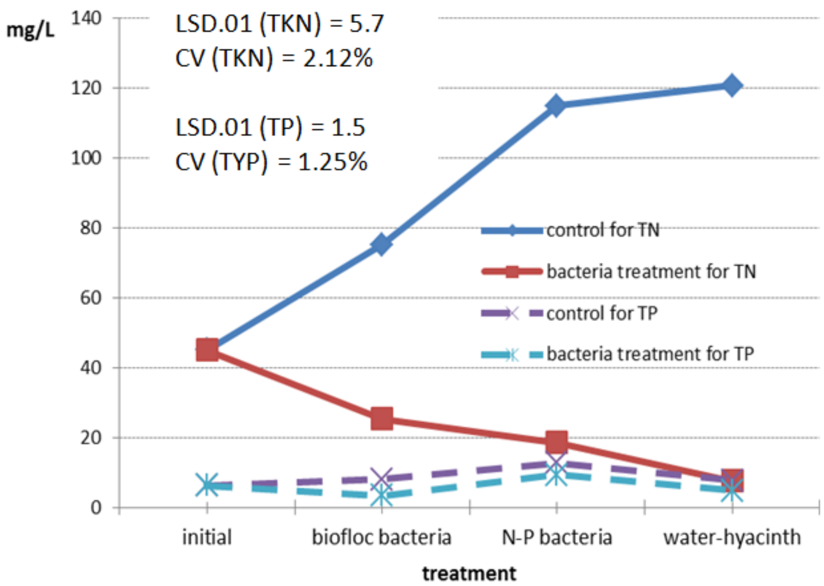

FIGURE 11. Effects of bacteria and water-hyacinth on TKN and TP concentrations of rice-noodle wastewater

Rice-noodle has been used for Thai cooking [23] and many countries in Asia (7). According to Pimpa [23], the manufacture of noodle using rice starch as a raw material produces a large volume of wastewater. The wastewater causes a considerable disposal or treatment problem because of its high biological oxygen demand (BOD) and total suspended solids (TSS).

After cellulose, starch is the second polysaccharide found in nature, produced by plants as reserve material. The main cultivated actually plants for the starch industrially production are cereals, especially corn, followed by wheat and potato [24]. Russ and Meyer-Pittroff, [25] recommend to appreciate the food waste by measuring the specific amount of waste production and determining the "specific waste index" which represent the mass of accumulated waste divided by the mass of the saleable product. Mironescu [26] recognized that starch and protein in wastewaters at potatoes processing worked for pH of wastewater decreased by fermentation of lactic bacteria. In rice-noodle processing, soaking rice for a long time is essential for producing naturally fermented rice-noodles. During this procedure, rice is soaked not only to absorb water, but also to allow natural fermentation to occur. Fermentation is facilitated by various microbes, especially lactic acid bacteria (LAB) [27] and yeast [28].

The effect of LAB and other bacteria during fermentation is a decrease in pH. The rice and soaking water have an initial pH of 7 (neutral) and this decrease to a pH of 4 when fermentation is complete [27] and in this study, pH of the supernatant decreased to 4.68 after 24 hr or 4.13 and 3.48 after 48 hr (Table 1). The main organic acids in the supernatant were lactic acid and acetic acid; Lactic acid was predominant [27], this indicated that some of the LAB involved were heterofermentative [29], pH of supernatant (or wastewater) will be good medium for heterotrophic bacteria releasing H_2S (a kind of not available gas).

Bioflocculant is a kind of biodegradable macromolecular flocculant secreted by microorganisms. Because of their biodegradability, harmlessness and lack of secondary pollution, bioflocculants have gained much wider attention and research to date (12). The actual application of this bioflocculant in rice noodle wastewater dewatering was investigated under a variety of conditions. Bioflocculants are widely useful in the treatment of water and wastewater, in downstream processing, and in processing of food and chemicals (30). In this study, application of bioflocculant-producing bacteria into rice-noodle wastewater supported organic matter solids as starch and/or protein precipitating down bottom. Gong *et al.* [31] observed that flocculating activity (%) reached to over 80% when pH of food wastewater (as meat, brewery, soy sauce brewing and river wastewater) was over 6.0 at 36 hr time with *Serratia ficaria* SF-1 strain. This led TSS concentration in wastewater decreased strongly (Figure 10) and pH of wastewater increased (Figure 9) and this result also helped heterotrophic nitrogen removal bacteria and poly-P bacteria acting effectively to remove nitrogen and orthophosphate out of wastewater (Figure 11). Besides, BOD_5 concentration reduced strongly due to the good action of the group bacteria effectively (Figure 10).

Bacteria with the ability of simultaneous heterotrophic nitrification and aerobic denitrification have been reported periodically [32]. Thus, the conventional nitrogen removal with the cooperation of different microorganisms under different conditions has been challenged. Ample literatures have been published on different strains such as *Pseudomonas stutzeri, Alcaligenes faecalis, Paracoccus denitrificans* and *Thiosphaera pantotropha* [33-35]. This kind of bacteria may have the potential to overcome the problems inherent in the conventional nitrogen removal process. The studies on heterotrophic nitrification and aerobic denitrification have focused on a low ammonium concentration that is discharged from domestic wastewater, and research on the treatment of high-strength ammonium wastewater is rare [36].

Alcaligenes faecalis strain No.4, which has heterotrophic nitrification and aerobic denitrification abilities, was used to treat actual piggery wastewater containing high-strength ammonium under aerobic conditions. In a continuous experiment using a solids-free wastewater (SFW) mixed with feces, almost all of the 2000 NH_4^+–N mg/L and 12,000 COD mg/L in the wastewater was removed and the ammonium removal rate was approximately 30 mg–N/L/h, which was 5–10 times higher than the rates achieved by other bacteria with the same abilities. The denitrification ratio was more than 65% of removed NH_4^+–N, indicating that strain No.4 exhibited its heterotrophic nitrification and aerobic denitrification abilities in the piggery wastewater [37].

Application of *Pseudomonas stutzeri* and *Acinetobacter lwoffii* to remove ammonia in wastewater of biowaste was carried out to evaluate their ability of ammonia removal at different concentrations with and without aeration condition in laboratory condition. The results showed that these species had ammonia removal ability effectively at both 50 mg/l and 100 mg/l ammonia concentrations. *Pseudomonas stutzeri* strain D3b and *Acinetobacter lwoffii* strain TN7 are the best bacterial species to remove ammonia. Besides that, both of species removed ammonia in aeration condition better than non-aeration condition. In three days, the ammonia removal efficiency of *Pseudomonas stutzeri* strain D3b were 97.2% and 98.57% and *Acinetobacter lwoffii* strain TN7 were 96.32% and 98.31% in 50 mg/l and 100 mg/l ammonia concentrations in wastewater of biowaste, respectively [38].

IV. CONCLUSION

Application of bioflocculant-producing bacteria, heterotrophic nitrogen removal bacteria, poly-P bacteria and water-hyacinth treated My Tho rice-noodle wastewater effectively and safety.

Treatment	Initial	control	Bacterial application*	40/2011 Standard (B level) Ministry of Natural Resource and Environment
pH	4.89	5.71	6.13	5.5 – 9.0
Total of Suspended Sodids (TSS) mg/L	369	31	17	100
Biological Oxygen Demand (BOD_5) mg/L	1200	200	23	50
Total Kjeldahl Nitrogen (TKN) mg/L	45.0	120	7.57	40
Total Phosphorus (TP) mg/L	6.3	7.57	4.76	6.0

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Effect of Compost, NPK and Plant Promoting Rhizobacteria (PGPR) on Growth and Yield of Three Vegetables cultivated on Arenosols

Tran Duy Phat[1]*, Tran Vu Phuong[2], Cao Ngoc Diep[3]

[1]Department of Agricultural Technology, Can Tho University, VIET NAM
*correspongding author
[2,3]Department of Microbiology Biotechnology, Can Tho University, VIET NAM

Abstract — *Three field studies were conducted to determine the effects of compost, plant growth promoting rhizobacteria (PGPR) and NPK on growth and yield of three vegetables. Two PGPR strains (Nitrogen-fixing Bradyrhizobium japonicum and Phosphate-solubilizing Bacillus subtilis) supplemented into compost and bacterial liquid were added into compost during vegetable cultivation, chemical fertilizer (100 N – 80 P_2O_5 – 40 K_2O) and control (non inoculation). The study revealed that compost inoculated with PGPRs can replace 50% chemical fertilizer in three vegetables cultivation, farmers but also saved 50 N – 40 P_2O_5 – 20 K_2O not only minimized environmental pollution.*

Key words - biomass yield, compost, PGPR, trade productivity, vegetable.

I. INTRODUCTION

Soil fertility degradation, caused by erosion and depletion or imbalance of organicmatter/nutrients, is affecting world agricultural productivity [1]. Inorganic fertilizers have played a significant role in increasing crop production since the “green revolution” [2]; however, they are not a sustainable solution for maintenance of crop yields [3]. Long-term overuse of mineral fertilizers may accelerate soil acidication, affecting both the soil biota and biogeochemical processes, thus posing an environmental risk and decreasing crop production [4].

Composting is considered a sustainable and environmental friendly approach for the safe utilization of solid organic wastes such as farm manure and trash of crops [5]. Usually, composts are applied to get equivalent amounts of nutrients but that requires a large amount of application rates. Increase in organic matter and vegetable production are seen in previous research at different levels (22.5, 56, and 112 t ha^{-1}) of compost application [6]. Some reports stated that application of composts improved the soil physical, chemical, and biological as well as yield of crops compared to chemical fertilizers on sustainable basis [7]. Mineralization of compost in the soil results in nutrient release and soil quality enhancement. The useful effects of application of composted organic materials on soils are very extensively recognized all over the world [8]. Total organic matter contents, microbial activity, and nutrient release are also increased with the application of composts [9]. Compost improves the physicochemical properties of soils such as pH cation exchange capacity, bulk density, porosity, and water holding capacity. The major concern associated with the use of organic manures is their rapid rate of decomposition especially under high temperature. Organic matter may be mineralized within a single cropping season and its sustainability is a standing question. Practically, some limitations are associated with the application of composts at higher rates containing some toxic constituents such as heavy metals [10-11]. Excessive applications of composts may release some organic compounds which can contaminate surface waters by runoff and subsurface water when percolates in deep layers [8]. This concern can be addressed with the value addition of composts in terms of higher stability and fertility for sustainable agriculture.

Vegetables are rich source of vitamins, proteins, carbohydrates and minerals, which constitute an important component in human nutrition. Besides the nutritional value of vegetables, increased interest is being bestowed on the functional and therapeutic benefits of vegetables in human health. Agriculture is highly dependent on the use of chemical fertilizers, growth regulators, fungicides and pesticides for obtaining increased yield. This dependence is associated with problems such as environmental pollution, health hazards, interruption of natural ecology, nutrient recycling and destruction of biological communities that otherwise support crop production. The use of bioresources to replace these chemicals is gaining importance. In this context, plant growth promoting rhizobacteria (PGPR) are often considered as novel and potential tool to provide substantial benefits to agriculture. [12].

PGPR are a heterogeneous group of bacteria that can be found in the rhizosphere, which can improve the quality of the plant growth directly and or indirectly [13] as (i) their ability to produce plant growth regulators like indoleacetic acid, gibberellic acid and cytokinins [14], (ii) asymbiotic nitrogen fixation [15], (iii) antagonism against phytopathogenic microorganisms by production of siderophores [16], antibiotics [17] and cyanide [18], (iv) solubilization of mineral phosphates and other nutrients [19] and (v) active removal and bioaccumulation of heavy metals and their capacity to assist the root growth [20].

In addition, PGPR isolates must be rhizospheric competent, able to survive and colonize in the rhizospheric soil [21]. The variability in the performance of PGPR may be due to climate, weather conditions, soil characteristics or the composition or activity of the indigenous microbial flora of the soil that may affect their growth and exert their effect on the plant [22]

Different bacteria that have been reported as PGPR belong to the following genera: *Pseudomonas, Bacillus, Azospirillum, Agrobacterium, Azotobacter, Arthrobacter, Alcaligenes, Serratia, Rhizobium, Enterobacter, Burkholderia, Beijerinckia, Klebsiella, Clostridium, Vario vovax, Xanthomonas, and Phyllobacterium* (23-24). Among these, *Pseudomonas* and *Bacillus* are the most widely reported PGPR.

The aim of this study was to evaluate the effects of composting and PGPR (including nitrogen-fixing bacteria and phosphate-solubilizing bacteria) on three vegetables (leaf-eating vegetable) as sweet cabbage (*Brassica integrifolia* O. B. Schultz), parchoi (*Brassica chinensis* L.), and mustard greens (*Brassica juncea* L.)

II. MATERIALS AND METHODS

2.1 Materials

2.1.1 Soil experiment

Soil experiment is arenosols [sandy soil] [25] with pH and physical and chemical characteristics of arenosols (Table 1). Soil experiment has neutral pH but soil fertility is low.

TABLE 1
pH AND PHYSICAL & CHEMICAL CHARACTERISTICS OF ARENOSOLS (SOIL EXPERIMENT)

Characteristics	
pH	7.53
CEC (meq/100g)	14.50
Organic matter (%)	1.13
Available N (mg/kg)	26.55
Available P (mg/kg)	168.37
Exchangeable K (mg/kg)	62,14
N total (%)	0.15
P total (%)	0.05

Origin: Analysed at Advanced Lad., Can Tho University, Vietnam, 2016

2.1.2 Composting procedure

Compost was prepared from rice straw (*Oryza sativa)*. The compost added with 0.02% *Trichoderma* spore (Dept. of Plant Protection, College of Agriculture, Can Tho University), incubated by covering plastic membrane; the compost was inverted and watering fortnightly. After 6 weeks, the volume of compost was reduced 50%, added liquid of PGPR (including nitrogen-fixing bacteria and phosphate-solubilizing bacteria) into compost to keep moisture at 50 – 60%, compost was incubated 4 weeks and compost from the bucket, air dried and later sieved to remove the shaft, shredded and bagged. Compost used in this study with pH and physical and chemical characteristics presented in Table 2.

2.1.3 PGPR production

Nitrogen-fixing bacteria [NFB] (*Bradyrhizobium japonicum* strain CJ02)[26] and Phosphate-solubilizing bacteria [PSB] (*Bacillus subtilis* strain SDN2c)[27] were provided by Biotechnology R&D Institute, CanTho University, Vietnam which proliferated by incubation in container 120-L containing 100 litres water with 10% sugar in 10 days for NFB and 7 days for PSB. PGPR liquid reached to 10^7 cells/ml and they already used to experiment.

TABLE 2
pH AND PHYSICAL AND CHEMICAL CHARACTERISTICS OF COMPOST SUPPLEMENTED WITH PGPR

Characteristics	Result	Comment
pH	6.68	Neutral
Available N (mg/kg)	134.17	High
Available P (mg/kg)	950.01	High
Exchangeable K (mg/kg)	5951.77	High
N total (%)	2.37	Normal
P total (%)	0.29	Normal

Origin: Analysed at Advanced Lab. Can Tho University, Vietnam, 2016

2.2 Experimental procedures

Three field experiments were done for three vegetables, the land for the field experiment was prepared manually. There were three blocks for each experiment, with each block consisting of five beds, making a total number of fifteen beds, with each bed measuring 1 x 3 m and 0.5 m in between beds, and block size of 17.5 x 4.5 m. The total land area used for each experiment was 78.75 m^2 (Figure 1). The seedlings were prepared in the plastic glasses (Figure 2) which were planted with one glass per hole at spacing of 0.4 x 0.30 m. The experimental design was a randomized complete block design. There were 5 treatments: NT1 (control, without fertilizer, compost, PGPR), NT2 (100 N- 80 P_2O_5 – 40 K_2O/ha), NT3 (2 kg compost/m^2), NT4 (3 kg compost/m^2), NT5 (4 kg compost/m^2). However, the treatments: NT3, NT4 and NT5 were supplemented into watering with time 1 (6 day after planting [DAP] with 50 ml/m^2, time 2 (9 DAP with 100 ml/m^2, time 3 (12 DAP) with 150 ml/m^2, time 4 (15 DAP) with 200 ml/m^2, time 5 (18 DAP) with 250 ml/m^2 and time 6 (21 DAP) with 300 ml/m^2 PGPR liquid.

FIGURE 1. Experimental plot as a bed, land were prepared by manually

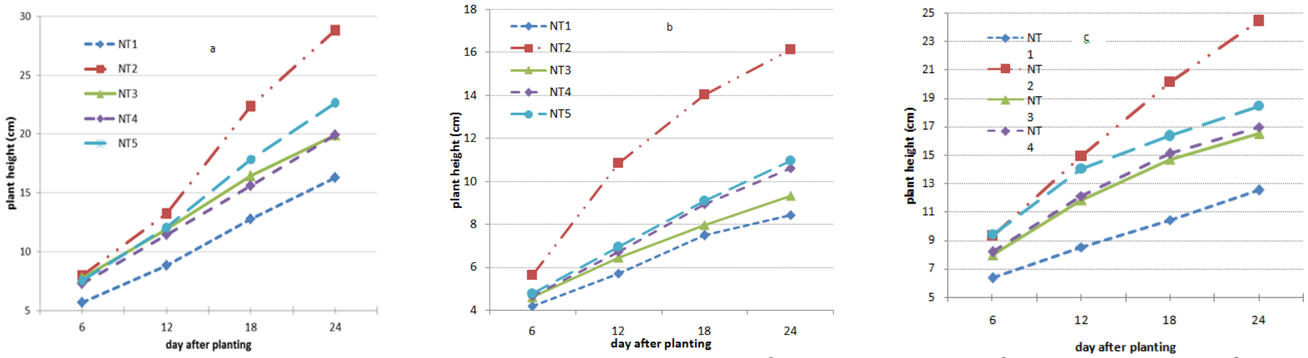
FIGURE 2. Seedlings were prepared to put in a hole

Insecticides did not used in the experiment, weed control by hand and eating-leaf plants were harvested at 24 days-old to measure plant height, leaf length, leaf number/plant, weight of a plant, biomass yield, Available ratio.

III. RESULTS AND DISCUSSION

3.1 Effects of compost on plant height and yield component of vegetables

Application of chemical fertilizer increased plant height of three vegetables and plant height was the lowest in the control treatment, using compost also increased plant height of three vegetables (Figure 3a, 3b and 3c).



NT1=control; NT2=100 N - 80 P_2O_5 – 40 K_2O/ha, NT3=2 kg compost/m^2, NT4=3 kg compost/m^2, NT5=4 kg compost/m^2

FIGURE 3. Effects of compost and PGPR strains on plant height of sweet cabbage (a)[left], pakchoi (b) [between] and mustard green (c) [right].

Similarly, the leaf length and leaf number/plant of chemical fertilizer treatment (NT2) were the higher than others significantly however leaf number/plant of mustard green in the NT3, NT4 and NT5 treatments did not differ from NT2 treatment (Table 3).

TABLE 3
EFFECTS OF COMPOST AND PGPR STRAINS ON LEAF LENGTH (CM) AND LEAF NUMBER/PLANT OF THREE VEGETABLES CULTIVATED ON ARENOSOLS.

Treatment	Leaf length (cm)			Leaf number/plant		
	sweet cabbage	pakchoi	mustard green	sweet cabbage	pakchoi	mustard green
Control	15.81 c	7.49 c	11.67 c	9.92 c	7.03 d	8.70 b
100 N - 80 P_2O_5 – 40 K_2O/ha	27.92 a	13.75 a	23.13 a	15.54 a	11.05 a	10.15 a
2 kg compost/m^2	18.24 bc	8.11 bc	15.62 b	11.30 bc	7.81 cd	9.59 ab
3 kg compost/m^2	19.12 bc	9.35 bc	16.12 b	11.57 b	8.44 bc	9.64 ab
4 kg compost/m^2	21.96 b	9.76 b	17.56 b	12.70 b	8.98 b	10.10 a
Calculated F	17.57**	17.33**	27.31**	23.05**	33.67**	4.48*
C.V (%)	**9.30**	**10.50**	**8.18**	**6.25**	**5.24**	**9.16**

***The numbers followed by the same letter do not differ at 1% level significantly*

3.2 Effects of compost on weight of a plant and biomass yield of vegetables

Application of chemical fertilizer for vegetable cultivation supported weight of a plant and biomass yield and using compost plus PGPRs also increased weight of a plant and biomass yield, application 4 kg compost/m^2 had the highest biomass yield but biomass yield also reached to 50% biomass yield of chemical fertilizer treatment, this showed that chemical fertilizer improved biomass of vegetable in short time in comparison to compost (24 days).

TABLE 4
EFFECTS OF COMPOST, NPK AND PGPR STRAINS ON WEIGHT OF A PLANT (G/PLANT) AND BIOMASS YIELD (KG/M2) OF THREE VEGETABLES CULTIVATED ON ARENOSOLS

Treatment	Weight of a plant (g/plant)			Biomass yield (kg/m^2)		
	sweet cabbage	pakchoi	mustard green	sweet cabbage	pakchoi	mustard green
Control	5.06 c	3.99 c	8.33 c	0.38 c	0.31 d	4.00 c
100 N - 80 P_2O_5 – 40 K_2O/ha	30.92 a	23.40 a	47.43 a	2.18 a	1.74 a	22.80 a
2 kg compost/m^2	12.53 b	4.33 c	19.00 b	0.85 b	0.40 cd	9.20 b
3 kg compost/m^2	11.65 b	7.48 bc	21.40 b	0.75 b	0.62 c	10.27 b
4 kg compost/m^2	16.71 b	11.24 b	26.77 b	0.99 b	0.92 b	12.80 b
Calculated F	262.29**	34.14**	27.27**	86.06**	57.69**	25.33**
C.V (%)	**5.96**	**23.50**	**19.46**	**12.93**	**16.36**	**20.18**

The numbers followed by the same letter do not differ at 1% level significantly

Available ratio (%) [trade productivity/biomass yield] depended on kind of vegetable as sweet cabbage had high available ratio (%) in control treatment but chemical fertilizer treatment had the lowest available ratio. On the contrary, on pakchoi, control treatment had the lowest available ratio and chemical fertilizer treatment had the highest available ratio. However, in all vegetables, compost treatment had stable available ratio (Table 5).

TABLE 5
EFFECTS OF COMPOST, NPK AND PGPR STRAINS ON BIOMASS YIELD (TON/HA) AND TRADE PRODUCTIVITY (TON/HA) OF THREE VEGETABLES CULTIVATED ON ARENOSOLS

Treatment	sweet cabbage			pakchoi			mustard green		
	biomass yield	trade product	Avai. ratio	biomass yield	trade product	Avai. ratio	biomass yield	trade product	Avai. ratio
	(ton/ha)		(%)	(ton/ha)		(%)	(ton/ha)		(%)
NT1	0.38 c	0.37 c	97.3 a	0.31 d	0.20 d	63.8 c	4.00 c	3.30 c	88.2 b
NT2	2.18 a	2.01 a	92.2 c	1.74 a	1.45 a	83.1 a	22.80 a	21.07 a	92.4 a
NT3	0.85 b	0.81 b	95.3 b	0.40 cd	0.29 cd	72.5 b	9.20 b	8.40 b	91.3 a
NT4	0.75 b	0.71 b	94.6 b	0.62 c	0.47 bc	74.6 b	10.27 b	9.20 b	89.6 ab
NT5	0.99 b	0.94 b	94.5 b	0.92 b	0.68 b	73.9 b	12.80 b	11.33 b	88.5 ab
Calcula. F	86.06**	79.63**	10.11*	57.69**	42.46**	9.62*	25.33**	24.35**	10.21*
C.V (%)	**12.93**	**13.24**	**6.11**	**16.36**	**21.73**	**5.21**	**20.18**	**21.60**	**5.48**

NT1=control; NT2=100 N - 80 P_2O_5 – 40 K_2O/ha, NT3=2 kg compost/m^2, NT4=3 kg compost/m^2, NT5=4 kg compost/m^2 trade productivity = trade product; Available ratio = Avai. Ratio = trade productivity/biomass yield (%); cal. F = calculated F

The numbers followed by the same letter do not differ at 1% level significantly

Application 4 kg compost/m^2 plus PGPRs for three vegetables cultivation had trade productivity more or less 50% in comparison to chemical fertilizer treatment (100 N – 80 P_2O_5 – 40 K_2O) (Figue 4) therefore the equivalent of 4 kg compost/m^2 or 40 tons/ha was calculated as 50 N – 40 P_2O_5 – 20 K_2O/ha or farmers not only saved 100 kg urea, 265 kg super phosphate 15% P_2O_5 and 33 kg KCl 60% K_2O but also kept safe vegetable products, consequently they contributed environmental protection.

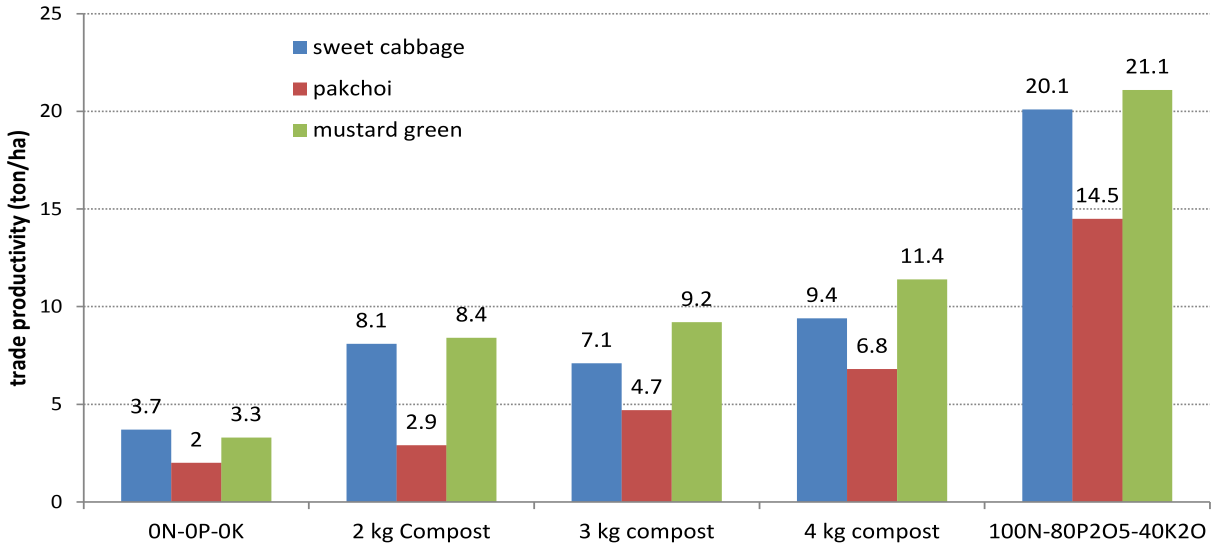


FIGURE 4. Effects of compost, NPK and PGPRs on trade productivity (ton/ha) of three vegetables cultivated on arenosols

Composts used as a soil amendment or in container media may protect plants from diseases caused by soilborne root pathogens [28]. Several organisms antagonistic to soilborne root pathogens have been isolated from suppressive composts [29]. These findings suggest that suppressive organisms may be at least partly responsible for the decreased disease incidence observed on plants grown in compost substrates. Compost generally increased growth rate, leaf area and dry matter accumulation of the two okra cultivars compared to control under varying light intensities. Compost at 15 t/ha performed better and increased fruit number by 66% on the field. The application of compost at 15 t/ha is therefore recommended for optimum yield of okra under low light intensity [30]. The use of compost with half fertilizer was better in increasing grain yield, especially with higher BC proportion in the compost than FM [31].

Plant rhizosphere is known to be the preferred ecological niche for various types of PGPR (*Rhizobium*, *Azotobacter* and *Azospirillium*) due to rich nutrient availability. The three main intrinsic characteristics of PGPR must be ability to: (i) colonize roots, (ii) survive and multiply in microhabitats associated with the root surface, in competition with other microbiota, at least for the time needed to express their plant promotion/protection activities, and (iii) promote plant growth [32-33].

The impact of rhizobacteria generally on plant growth and health may be classified as neutral, deleterious or beneficial (34). However, PGPR specifically are beneficial and the beneficial effects have been utilized in many areas including biofertilizer, disease control, microbe-rhizoremediation, biopesticide, in forestry as well as probiotics (35). Plant growth-promoting rhizobacteria (PGPR) benefit plants through different mechanisms of action, including, for example, (i) the production of secondary metabolites such as antibiotics, cyanide, and hormonelike substances; (ii) the production of siderophores; (iii) antagonism to soilborne root pathogens; (iv) phosphate solubilization; and (v) dinitrogen fixation [36]. The establishment in the rhizosphere of organisms possessing one or more of these characteristics is interesting since it may influence plant growth. The effect of PGPR in crop productivity varies under laboratory, greenhouse and field trials. Because, soil is an unpredictable environment and an intended result is sometimes difficult to achieve. Plant growth promoting traits do not work independently of each other but additively as it was suggested in the ‘‘additive hypothesis,’’ that multiple mechanisms, such as phosphate solubilization, dinitrogen fixation, ACC deaminase and antifungal activity, IAA and siderophore biosynthesis etc. are responsible for the plant growth promotion and increased yield [37]. Chabot *et al.* [38] used phosphate-solubilizing *Rhizobium leguminosarum* biovar phaseoli on lettuce and Antoun *et al.* [39] also used *Rhizobium* and *Bradyrhizobium* species on ridishes *(Raphanus sativus* L.) and they noticed positively from these rhizobia species.

Kalita *et al.* [40] showed that the mixture of PGPRs increased the shoot height, number of leaves, and total biomass content of plants as tomato, chili, cauliflower, brinja after treatment. Kumar *et al.* [41] recognized that bitter gourd with plant growth promoting rhizobactreia (PGPR) enhanced its growth, yield and quality attributes, especially with *Bacillus subtilis.* In the experiment in Long An province, using 15 ton/ha compost + 35 N – 24 P_2O_5 – 12 K_2O had biomass yield of mustard green was equivalent with 70 N – 48 P_2O_5 – 24 K_2O kg/ha without compost but compost treatment only had 4.78 mg/kg nitrate in biomass while chemical treatment had 286 mg/kg nitrate [42]. The results of effects of compost plus PGPRs on mustard green cultivated on alluvial soil of Can Tho city showed that biomass yield of treatment compost (1 ton/ha plus 50 N – 40 P_2O_5 – 20 K_2O kg/ha) in did not differ with biomass yield of chemical fertilizer treatment (100 N – 80 P_2O_5 – 40 K_2O kg/ha) without compost but nitrate content in leaves of mustard green was low [43]. Our result showed that the effectiveness of compost plus PGPRs (nitrogen-fixing rhizobia and phosphate-solubilizing bacilium) on three vegetables cultivated on arenosols only reached to 50% biomass yield of chemical fertilizer treatment.

IV. CONCLUSION

Compost was produced from rice straw and *Trichoderma* spore, supplemented with PGPRs (Nitrogen-fixing *Bradyrhizobium japonicum* and Phosphate-solubilizing *Bacillus subtilis*) and its effect on three vegetables cultivated on arenosols reached to 50% amount of chemical fertilizers both biomass yield and trade productivity.

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Resistance in Plants, Concepts and Mechanisms

Firoozeh Chamandoosti

Iranian Research Institute of Plant Protection, Agricultural Research, Education and Extension Organization (AREEO), Tehran, Iran PhD of Cellular and Developmental Biology, Assistant Professor of Iranian Research Institute of Plant Protection Department of Plant Diseases

Abstract— *In contrast to most animals, plants are sessile organisms that they have not a circulatory system. So they have an innate immune system in each cell. In fact interaction between plants and their pathogens is based on systemic signaling capability from infection sites. In plant pathogen interaction sometimes pathogens produce elicitor and sometimes produce effector. On this basis, resistance in plants is divided to host and non host. On the other hand the plant responses depend not only on the recognition mechanisms but also very much on the biology of the interactions and genetic characteristics of plants and their pathogens. Gene – for – gene and the matching allel are two basic models for explanting of genetic basis of interaction between plants and their pathogens.*

***Keywords—* Effector, Elicitor, Qualitative Resistance, Quantitative Resistance, Plant Resistance.**

I. INTRODUCTION

Have you ever thought that which of the two are more dangerous for humankind? Plant diseases or human diseases? Have you ever thought that all of kind of organisms from very small living things which have not even complete structural cell to human who is masterpiece of creation use green plants? So plants or green plants have a lot of consumers. If plants cannot defense against this wide spread range of consumers the human health is threatened. The role of plants not only in our foods but also in our dressing and or in bioproduct production either under field conditions or in storage is so clear that it dose not require additional explanation. So plants as benefactors of world must be able to combat with their risk factors and use from defense mechanisms that are principally based on avoidance, resistance or tolerance [11].

Avoidance is mainly active against animal parasites and includes such diverse mechanisms as volatile repellents, mimicry and morphological features like hairs, thorns and resin ducts. Resistance is usually of a chemical nature. Little is known of tolerance; it is very difficult to measure and is usually confounded with quantitative forms of resistance [27].

Resistance in plants can include two basic form, quantitative and qualitative [3]. Also the other forms that all of them are based on the genetic characteristics of plants and their pathogen agents especially the interactions of these two factors. On the other hand the study of these genetic traits is very important because genetic improvement of plants is the best way to manage of damage caused by plant diseases.

II. BASIC CONCEPTS

2.1 Elicitors and Effectors

Before any explanation about these basic concepts it must be clear that in contrast to most animals, plants are sessile organisms, they lack a circulatory system and their cells are framed with a rigid cell wall. These evolutionary constraints have resulted in the evolution of a primary cell – autonomous immune system [56]. In fact they have innate immune system in each cell with systemic signaling capability from infection sites [21].

In plant pathogen interaction, sometimes pathogens produce elicitor and sometimes produce effector. Elicitors such as peptides, metabolites, cell wall components, enzymes, and toxins are produced for suppressing plant defense [78]; [60]; [50] and [46] and are called pathogen/microbe – associated molecular patterns (PAMP/MAMP). These elicitors produce non – host disease resistance and have the ability to reduce the disease severity of actual pathogens (basal disease resistance) [57]. In this kind of resistance, following pathogen attack plant signal molecules are produced by damaged host that are named damage – associated molecular patterns (DAMP) [78]. These elicitors or PAMP/ MAMP/DAMP are recognized by the pattern recognition receptors (PRRs) that are biosynthesized in endoplasmic reticulum and transported to plasma membrane [47]. As a first line of defense response, the PAMP/MAMP trigger downstream genes resulting in no symptoms or race – non – specific hypersensitive response, generally referred to as the PAMP/pattern – triggered immunity (PTI) or non – host resistance [2]; [78]; [60]; [6] ; [76]; [45] and [7].

So elicitors induce similar defense responses in plants as induced by the pathogen infection [61].

And also nonhost resistance is a broad – spectrum plant defense that provides immunity to all members of a plant species against all isolates of a microorganism that is pathogenic to other plant species. Upon landing on the surface of a nonhost plant species, a potential bacterial pathogen initially encounters preformed and, later, induced plant defenses. This nonhost resistance response often results in a hypersensitive response (HR) at the infection site [53].

III. NON HOST RESISTANCE AND HYPERSENSITIVE RESPONSE (HR)

Plant immunity against the majority of microbial pathogens is conveyed by a phenomenon known as non – host resistance (NHR) [49]. This defence mechanism affords durable protection to plant species against given species of pathogens. This contrasts with the well – studied host resistance, mediated by the products of plant resistance (R) genes, which establish pathogen race – or cultivar – specific resistance. Whereas NHR routinely provides durable crop protection in the field, the effectiveness of host – resistance is characteristically transient.

The broad – spectrum nature of NHR closely parallels that exhibited by the innate immune system of animals. NHR, however, has proved difficult to characterise as a result of the absence of a tractable genetic system. It is thought to be genetically complex, involving the deployment of both constitutive and inducible defence responses, in combination with a host physiology that may be routinely incompatible with pathogenesis.

One of the most dramatic visible phenotypes that is frequently (but not always) associated with plant resistance is rapid localized cell death, the hypersensitive response (HR), at the site of infection, which is often compared with animal programmed cell death. This is an especially effective process in limiting pathogens that require living host cells [30].

The HR occurs in plants in response in infection by plant pathogenic fungi, bacteria and viruses. When an HR occurs the plant dose not succumb to infection and damage to the plant is limited to the cells in HR lesion. The mechnisms involved in generation the HR and ultimately causing resistance have been the subjects of intensive research. Much of research has been carried out with simplified experimental systems e.g. with fungal components called elicitors that they was mentioned above. These components cause necrosis in whole plant tissues or plant cell suspension cultures. The HR caused by plant pathogenic bacteria has also been studied. Historically this was because of the possibility of separating prokaryotic (pathogen) metabolism from eukaryotic (host) metabolism by using selective antibiotics and more recently because of the relative ease of using molecular genetics methodology on the pathogen. The HR can also be induced by viruses and a similar phenomenon has been reported in resistance of plants to some nematodes. Information about the HR has been obtained by studying many different host plants, such as *Arabidopsis*, barley, bean, cucumber, lettuce and tomato in response to viruses, bacteria, fungi, or a whole range of different elicitor molecules. The HR has been investigated in whole plants or in cell culture system. Thus it is perhaps wise to treat generalizations with caution while trying at the same time to sift out a unified picture of the HR as far as possible from the mass of information available from different experimental systems [80].

IV. EFFECTORS AND HOST RESISTANCE IN PLANTS

As it was mentioned earlier in plant pathogen interaction sometimes pathogens produce effector. Specialized pathogens produce race – specific intracellular elicitors called effectors, produced by specific avirulence (AVR) genes [78] and [69]. Though these are considered to be specific to biotrophs, several necrotrophs also produce effectors [78]. These effectors suppress other PAMPs and also the host resistance genes to become more virulent [44]. The effectors, depending on their domains, are recognized by plant – produced specific receptors (R proteins), encoded by R genes [78]; [22]; [21] and [58]. As a second line of defense response, the effectors trigger downstream genes resulting in race – specific hypersensitive response to contain the pathogen, generally referred to as the effector triggered immunity (ETI), qualitative resistance, or vertical resistance [78] and [50]. Such a resistance is considered to be monogenic and spawned the gene – for – gene hypothesis [18]. However, these effector recognition receptor genes are just surveillance genes and the real resistance genes that induce hypersensitive response are NADPH oxidase, callose synthase, etc., The genotypes rendered susceptible are considered to vary in basal resistance, partial resistance, or horizontal resistance [32]; [68] and [60].

V. HOST AND NONHOST RESISTANCE – SIMILARITIES AND DIFFERENCES

Given that host pathogens and nonhost pathogens can be recognised by similar mechanisms, it is not surprising that numerous studies have documented that defence responses to host pathogens and nonhost pathogens are also similar. However, the plant responses depend not only on the recognition mechanisms but also very much on the biology of the interactions, and so it is difficult to make useful comparisons between an incompatible host – pathogen interaction and a nonhost – pathogen interaction. Any statement on the similarity of responses should therefore be based on closely related host and nonhost pathogens. A novel study of the expression of about 8000 *Arabidopsis* genes in response to different strains of *Pseudomonas syringae* [82] would seem to meet this criterion. There is a problem, however, in that the nonhost pathogen used in this study, *Pseudomonas syringae* pv. *phaseolicola*, does not activate HR [52], unlike the avirulent host pathogens that were used for comparison. Nevertheless, changes in the expression of approximately 2000 response genes were largely shared among two incompatible interactions, which were mediated by single R genes, and the nonhost interaction [82]. Currently, comprehensive gene expression arrays are being generated for barley and wheat, and these will allow interesting comparisons of host and nonhost resistance. Closely related fungal pathogens that have apparently identical infection biology exist for these cereals, but they are strictly separated in host and nonhost pathogens. The best example may be the formae speciales of the powdery mildew fungus.

Efforts have been made to elucidate whether the defence signalling steps known from host resistance are shared by nonhost resistance. The ENHANCED DISEASE SUSCEPTIBILITY1 (EDS1)[1] protein, which is necessary for R – gene – mediated resistance to many pathogens in *Arabidopsis* [55] is also important for nonhost resistance to isolates of *Peronospora parasitica* and, which are pathogenic on closely related Brassicas [24]. Furthermore, a recent study of the role of the plant SUPPRESSOR OF G2 ALLELE OF SKP1 (SGT1)[2] protein in resistance to different diseases supports the idea that host and nonhost plants share certain defence signaling components [36]. In yeast, SGT1 plays a role in SCF (Skp1 Cullins[3] F – box proteins) E3 – ligase – mediated ubiquitylation and may regulate a number of R – protein functions [59]. As a result of silencing studies of SGT1 in *Nicotiana benthamiana*, this list was expanded to include the non LRR (Lucin rich repeat) R gene Pto[4] [36]. Interestingly, nonhost resistance to two bacterial pathogens also requires the SGT1 protein [36]. Nevertheless, resistance to the nonhost bacterium *Xanthomonas campestris* pv. *campestris* and to Cauliflower mosaic virus (CaMV), a nonhost virus, were not affected by the silencing of SGT1. Salicylic acid (SA) signaling in host resistance has received much attention over the years [35], but the extent to which it is involved in nonhost resistance remains unclear. Degradation of SA in *Arabidopsis* salicylate hydroxylase (NahG) lines confers susceptibility to the nonhost bacterium *P. syringae* pv. *phaseolicola* [52]. New observations suggest, however, that this is caused by the catechol that is produced during the degradation of SA [74]. Hence, even though this nonhost bacterium has nonhost avr – genes [37] that may have corresponding R genes in *Arabidopsis*, the interaction of these genes may be overruled by strong general elicitors that activate innate immunity. Interestingly, *Arabidopsis* manifests no HR to infection by *P. syringae pv. phaseolicola* [55], neither does it manifest an HR during general elicitor mediated innate immunity [42]. However, this innate immunity does seem to involve signalling components that are shared with R – gene – mediated signaling [43]. An *Arabidopsis* mutant, nho1 (for nonhost resistance1), has been isolated on which *P. syringae* pv. *phaseolicola* grows and causes disease symptoms [52]. It is significant that this mutant is also compromised in R – gene – mediated resistance to *P. syringae*. These observations should be kept in mind when interpreting the recent genomic study which shows that the response of 2000 *Arabidopsis* genes to *P. syringae* pv. *phaseolicola* is slowed and reduced as a result of NahG –mediated degradation of SA [82].

VI. GENETIC BASIS OF HOST AND NONHOST RESISTANCE

6.1 Avirulence genes and resistance genes

Virulence gene is a gene that, during the disease process, codifes the production of factors that alter host – cell structures and functions [14].

Avirulence genes in pathogens are those genes that confer the ability to be recognized by a resistant host plant [30]. A number of avirulence genes have been cloned from plant pathogens, particularly viral and bacterial avirulence genes [62]. Viral avirulence genes encode a range of functions including capsid proteins and replicase proteins. Comparison of the gene products of bacterial avirulence genes shows that they are mostly unrelated and their function is largely unknown. There is

[1] - Positive regulator of basal resistance and of effector-triggered immunity specifically mediated by resistance proteins such as TIR-NB-LRR (TNL) that is Toll interleukin-1 receptor-like nucleotide-binding site leucine-rich repeat

[2] - an iated disease resistanceessential component of *R* gene-med in plants

[3]- are a family of hydrophobic scaffold proteins which provide support for ubiquitin ligases (E3). All eukaryotes appear to have cullins. They combine with RING proteins to form Cullin-RING ubiquitin ligases (CRLs) that are highly diverse and play a role in myriad cellular processes, most notably protein degradation by ubiquitination [8].

[4] - The Pto gene encodes a serine-threonine kinase that confers resistance in tomato to *Pseudomonas syringae* pv tomato strains expressing the avirulence geneavrPto.

now evidence that the bacterial avirulence gene products are introduced into plant cells by a type III secretion mechanism[5] [48]. Further evidence suggests that these gene products are involved in enhancement of bacterial virulence (in the absence of the corresponding host resistance gene) and so are analogous to the virulence effector proteins delivered to animal cells by mammalian bacterial pathogens [83]. Only a few fungal avirulence genes have been cloned owing to the more complex genomes of fungi. The products of these genes include small, secreted proteins of unknown function [62]. In one case, a fungal avirulence protein from the rice blast fungus has similarity to a zinc protease [12]. Pathogens require signals from the plant to induce cell differentiation and express essential pathogenicity genes. This requirement for cues from the plant is obvious for rust fungi, in which hyphal differentiation is induced by the surface topography of the plant [15]. A recent study of the barley powdery mildew fungus (*Blumeria graminis* f. sp. *hordei* [Bgh]) suggested that the composition of the surface wax is important in activating the development of a differentiated appressorium [54]. Wax composition could therefore be involved in determining whether plants are hosts or nonhosts. Presence of preformed barriers is often claimed to be a first line of plant defence. Conceptually, preformed plant cell walls, antimicrobial enzymes, and secondary metabolites would be ideal early obstacles for the pathogen. These barriers are undoubtedly important in defence against many host and nonhost pathogens, but their success in preventing disease probably depends on the degree of co – evolution of the pathogen and host. However, little documentation is available on the role of preformed defences. Nevertheless, one example in which a host pathogen is adapted to overcome a preformed antimicrobial compound, whereas a closely related nonhost pathogen is not, clearly confirms that preformed barriers can provide important defences. The wheat root pathogen *Gaeumannomyces graminis* var. *tritici* is not adapted to attack oats successfully and cannot cause disease on oat roots. The related oat root pathogen *G. graminis* var. *avenae* depends on its ability to detoxify avenacin A – 1, an antimicrobial saponin, to proceed in its life cycle. A mutant oat line, which no longer expresses avenacin A – 1, is susceptible to *G. graminis* var. *tritici*. It appears therefore that *G. graminis* var. *tritici* is a nonhost pathogen of oats because it lacks the enzyme that detoxifies avenacin [41]. Plants can mount several barriers in response to attack by both host and nonhost pathogens, and these responses can be independent of the genotype of the individual pathogen. 'General elicitors' may be released during attacks by both host pathogens and nonhost pathogens, and the barriers that are activated in response to these elicitors contribute to resistance towards both types of microbes. Flagellin, a protein of the bacterial flagella, serves as such an elicitor. This protein activates defence through a pathway that involves FLAGELLIN INSENSITIVE2 (FLS2), a leucine – rich repeat (LRR) receptor kinase and a mitogen – activated protein (MAP) kinase cascade [77]. Other general elicitors are released during the enzymatic degradation of pathogen cell – wall polymers, when the pathogen is making its way into the host. This group of elicitors include oligomers of chitin and glucans. Flagellin and oligomers, released from pathogen cell walls, typically activate the production of antimicrobial proteins and phytoalexins (antimicrobial secondary metabolites) in the plant tissue. Such general elicitors are often indispensable to the microbe, and plants are suggested to exploit them during recognition in the same way as animals recognise PAMPs [24]. The use of general elicitors together with the involvement of an LRR – receptor kinase and a MAP kinase[6] cascade make this defence mechanism reminiscent of animal 'innate immunity' systems, suggesting a shared ancient system for combating invaders [77]. Other examples of defence mechanisms that have similarities to innate immunity are the activation of defence in parsley and potato nonhost plants by Pep – 13 , a peptide fragment from *Phytophthora sojae* [10], and the activation of defences in nonhost tobacco by the 'harpin' protein of *Pseudomonas syringae* [33]. These plant responses certainly impede pathogen proliferation in a quantitative manner, but their contribution to nonhost resistance is not entirely clear. An example of an inducible structural barrier, which is potentially activated by general elicitors, is the papilla. This local cell wall fortification is formed on the inner side of plant cell walls at the site of fungal penetration. The papillae formed in response to powdery mildews are well studied and serve a significant role in keeping the fungus out [16] and [65]. A case of papilla – based resistance, which is unusual because it gives complete protection, is the barley mlo[7] – resistance to the *Blumerie graminis* f. sp. *hordei* (Bgh) host pathogen. MLO

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[5] - (often written Type III secretion system and abbreviated TTSS or T3SS, also called Injectisome) is a protein appendage found in several Gram-negative bacteria. In pathogenic bacteria, the needle-like structure is used as a sensory probe to detect the presence of eukaryotic organisms and secrete proteins that help the bacteria infect them. The secreted effector proteins are secreted directly from the bacterial cell into the eukaryotic (host) cell, where they exert a number of effects that help the pathogen to survive and to escape an immune response.

[6] - A mitogen-activated protein kinase (MAPK or MAP kinase) is a type of protein kinase that is specific to the amino acids serine and threonine.

7- The Mlo-related proteins are a family of plant integral membrane proteins, first discovered in barley. Mutants lacking wild-type Mlo proteins show broad spectrum resistance to the powdery mildew fungus, and dysregulated cell death control, with spontaneous cell death in response to developmental or abiotic stimuli.

negatively regulates papilla formation, and so mutations in this gene cause resistance [5]. Papillae are also important in nonhost resistance. In wild type *Arabidopsis*, about 80% of the conidia of the nonhost pathogen Bgh are stopped in association with papillae. These mutants have been studied to study nonhost resistance. Mutations in the PENETRATION1 (PEN1) and PEN2 genes reduced the plants' ability to arrest Bgh – conidia to about 20% of that of wild type plants. The identity of PEN1 strongly suggests the importance of vesicle trafficking in penetration resistance. (Mutation in PEN2 cause constitutive cell wall changes, and therefore this gene may represent a defence mechanism [16]. The *pen* mutants are paralleled by the required for MLO – specified resistance1 (ror[8]1) and ror2 mutants in barley. These ror mutants were isolated as suppressors of mlo – resistance and, like the *pen* mutants, they reduce penetration resistance to Bgh significantly [5]. Significantly, the barley ROR2 gene is a functional homologue of the *Arabidopsis* PEN1 gene [16]. This discovery strongly suggests that elements of papilla – related vesicle trafficking are conserved between host and nonhost resistance, even in these distantly related plant species.

Many ideas have been documented in an attempt to explain the genetic basis of host resistance to pathogens. The gene – for – gene model refers to a specific genetic interaction between a host and its pathogen. It states that a resistance gene (*R* gene) in the host and an avirulence gene (*Avr* gene) in the pathogen must be present for the host to be resistant. *R* genes in the host recognize *Avr* genes in the pathogen and a defense response is activated preventing the establishment of the pathogen in the host. [18]. was the first to discover and present this matching specificity between host and pathogen genes. His work in selective crop breeding with flax lead to the rather unintentional detection of this interaction between this plant and its fungal pathogen, flax rust. He showed that for every gene in the plant that conditioned resistance, a corresponding and complementary gene in the pathogen that conditioned avirulence existed [64]. Since the initial proposal of this gene – for – gene idea evidence for its presence has been presented for over 25 different plant host – pathogen pairs [72]. However, this proposed gene – for – gene interaction between host and pathogen is controversial. Evidence for this interaction has almost exclusively been found in plants and more specifically agricultural crops [1] and for many reasons this model, although it exists, may not be applicable to a wide selection of host – pathogen interactions. Crop plants are subject to strong artificial selection. Interestingly there is increasing evidence to suggest that the intensity of selection may influence the number of genes involved in [34]; [20] and [38]. So it is possible that evidence for a simple gene – for – gene interaction in crop plants is the result of artificial selection of only a small subset of genes which would have been selected to defend plants from pathogens under natural conditions. In addition, most crops are grown in stable and often optimized conditions and exposed to minimal competition with other species [19]. The size of crop plant populations are also controlled and therefore fluctuate less through time than natural populations [19]. It is important to consider the contribution that both artificial selection and growing conditions may have on the nature of the genetic interaction between hosts and pathogens when assessing the wider applicability of the gene – for – gene view. The lack of evidence for this interaction in natural populations supports the observation that this model may have limited application outside crop plant – pathogen interactions. Indeed the attraction of this theory may be its simplicity rather than its accuracy [71]. Investigation of the genetic basis of host resistance to pathogens continued following the initial proposal of the gene – for – gene view by [18] leading to the development of more sophisticated models. Another view termed the matching – allele model has been presented to explain the genetics underlying host resistance [72]. This model suggests each host allele confers resistance to one parasite allele. Resistance in the host occurs when its genotype and that of its pathogen match exactly. For successful infection by the pathogen to occur the genotype of the host and pathogen must not match. In contrast to the gene – for – gene model, which predicts that parasite host range will vary greatly, the matching – allele model predicts that all parasites can attack the same number of hosts [23]. Whereas the gene – for – gene model has been important in the understanding of host pathogen interactions in plants, the matching – allele model is favored by zoologists [1]. A matching – allele interaction has been documented in both studies with invertebrates [66] and vertebrates [31]. However, overall there is little experimental support for this alternative genetic scenario [23] and [39]. Although the gene – for – gene model and the matching – allele model have been considered independent in much of the literature it has been suggested that they are in fact two ends of a continuum [1]. Assessment of allele frequency dynamics along this continuum revealed that the variance of allele frequencies under a gene – for – gene system can strongly approach those predicted by matching – allele models if the costs of virulence and resistance are great [1]. In light of such findings there may be doubt as to how the two models can be discriminated between given certain data [73] and [13]) and it is possible that results of past studies based on allele frequency variance may be misinterpreted and

8- RAR-related orphan receptors (RORs) are members of the nuclear receptor family of intracellular transcription factors.

fitted to the wrong model [73]. Rather than considering both models as being equally likely to explain the results, it may be that if the results fit what could be the outcome of the gene – for – gene model the matching – allele model will not be considered. The consideration of both models in explaining empirical data is necessary given their convergence under certain conditions. According to neodarwinian theory traits which evolve at the highest rate will be those that are controlled by genes at many loci which each have a small effect [34]. Evidence suggests that commonly the evolution of resistance to pathogens is relatively rapid [79]. The gene – for – gene model and the matching – allele model suggested to account for host resistance are based on the interaction at one genetic locus only and therefore contrast this prediction [70].

VII. OTHER FORMS OF DIVISION OF PLANT RESISTANCE

7.1 Qualitative and quantitative resistance

Resistance, like other traits, occurs in a qualitative or in a quantitative way. With the former the different genotypes in a population occur as discernible phenotypes; it is usually controlled by a major gene. Quantitative resistance (QR) is defined as a resistance that varies in a continuous way between the various phenotypes of the host population, from almost imperceptible (only a slight reduction in the growth of the pathogen) to quite strong (little growth of the pathogen). This resistance is often indicated with other terms such as partial, residual and field resistance or even (wrongly) with tolerance. QR occurs at various levels to nearly all important pathogens in most cultivars of our crops. For example barley and barley leaf rust, *Puccinia hordei*. The QR to this pathogen inherits polygenically [26] and all cultivars in Western Europe, including the very susceptible cultivars, carry at least some QR. Most cultivars, though, carry considerable levels of QR, preventing the barley leaf rust from becoming a major pathogen in Western Europe [27]. In Ethiopia the barley landraces represent a centre of diversity. Barley genotypes without any QR are very rare [4]. Also Wheat/yellow rust, wheat/leaf rust, and barley/powdery mildew. Breeding in Western Europe is directed at selecting major genes of the non – durable type to protect against these three major pathogens. In this way, new recommended cultivars tend to enter the recommended cultivar list with high scores for resistance. After a number of years these scores are much lower as the major gene resistance is not effective any more. After the resistance “breaks down”, QR becomes visible if present. All cultivars selected for their major gene resistance appear to carry moderate to fair levels of QR hidden behind that major gene. This hidden QR is sometimes indicated as residual resistance.

Therefore, QR is present almost everywhere. Cultivars without any QR are very rare. For this type of resistance breeders do not need to look for primitive genotypes from centres of diversity nor to related wild species. The resistance is near at hand in adapted cultivars, a fortunate situation as it makes breeding easier. [63] concluded that the ideal sources of resistance are those present in closely related, commercial genotypes, and any effort to transfer resistance from related species and genera should be considered long term. QR is, except for a few cases of monogenic, incomplete inheritance, inherited oligogenically or polygenically. Examples of the former are the QR of maize to *Puccinia sorghi* Schw [75] and of wheat to *Puccinia recondita* [42], based on a few (two or three) additive genes. Polygenic QR is exemplified by the field resistance of potato to *Phytophthora infestans* [81] the QR of maize to [*Cochliobolus heterostrophus* (Drechsler)] and [*Setosphaeria turcica* (Luttr)] [40], in rice to bacterial blight [51] and of barley to *Rhynchosporium secalis* (Oud.) Davis. [67] and to *Puccinia hordei* [26], and of rice to [*Magnaporthe grisea* (T.T. Hebert) Yagashi and Udagawa] [9]. Polygenic QR is usually supposed to be non race specific, but does not appear to be so. In the polygenic pathosystems mentioned above, small race – specific effects have been reported [25] and it is probable that polygenic resistance to specialized pathogens often goes together with small race – specific effects. [28] described this in the following way: When resistance in the host and aggressiveness in the pathogen interact on a polygene – for – polygene basis and several host cultivars are tested against a series of pathogen isolates the general impression is that of non – race – specificity. Most variation is between cultivars and between isolates. If the accuracy of the experiment is sufficiently high small but significant race – specific effects can be observed.

VIII. BREEDING AND RESISTANCE

In order to reduce costs and to increase the efficiency of identifying resistant plants or lines in segregating populations, breeders developed screening methods in which plants as young as possible were exposed to high concentrations of, preferably, a specified inoculum. This efficiently identifies complete resistance based on major genes but is inadequate for recognizing small differences in resistance. These screening approaches, together with the belief that polygenic resistance is difficult to select for and might not give a good level of resistance, led to the present situation where major gene resistance has been exploited very well, while QR has been used only sparingly. This is unfortunate as there is so much QR available. Quantitative resistance occurs to most of our important pathogens at various levels in nearly all our crops as discussed under ‘‘Quantitative Resistance.’’ Since this QR occurs in the cultivars grown, it is genetic material that is related to what the breeders' desire. For this type of resistance breeders do not need to look for primitive genotypes from centres of diversity nor to related wild species. The resistance is near at hand in adapted cultivars, a fortunate situation as it makes breeding easier. [63] concluded that the ideal sources of resistance are those present in closely related, commercial genotypes, and any effort to transfer resistance from related species and genera should be considered long term. To select for QR means accumulating QR in much the same way as selecting for higher yields. The breeder selects the plants or lines with the lower levels of disease severity and by doing that continuously over the seasons, the level of QR will increase fairly rapidly as [29] showed. There is, however, one complication. If there is also non – durable major gene resistance around, it has to be taken into account. The QR is not visible when such an effective major gene is present. By using, preferably, local material, the frequency of such non – durable still effective major genes is often low, as the local pathogen population has adapted to these genes. Introducing plant material from elsewhere, especially from the centres of diversity, increases the frequency of such non – durable effective major genes considerably, as the local pathogen population has not yet adapted to the newly introduced resistance. Therefore, to select QR stick as much as possible to local material as they will almost certainly carry QR. One can also avoid ending up with non – durable major resistance in the selected material by selecting against susceptibility, i.e. removing the most susceptible plants and lines all the time [29]. Plants or lines with complete resistance should also be removed in case of resistance breeding against specialized fungal pathogens, as such resistances can be assumed to be non – durable. In case of non – specialized pathogen and virus's one may use any resistance [11].

IX. CONCLUSION

In nature organisms are divided to producers and consumers. Green plant are the most important of producers so that without them life in planet earth is impossible. All of our efforts for understanding of mechanisms of interaction between plants and their pathogens are for production of more food and better food. For this purpose we need to more and better understanding of mechanisms that interfer in plant resistance. These studies are in different levels. At this time the study of basis genetic of resistance (of plants against pathogen) is very important. With the possibility of isolating specific genes that they have desirable characteristics it becomes possible to make genetic constructs by combining genes from different origins or even by changing the isolated genes. The possibilities are almost infinite and each construct has to be tested.

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