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Effect of Organic and Inorganic Fertilizer on the Physicochemical Properties of Some Rice Varieties under Sudan conditions

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Abstract:

Field experiments were conducted at the experiment field of college of Agriculture Studies, Sudan University of Science & Technology, (Lat. 15^0 40'N, Long. 32^0 32'' E), to observe the influence of organic and inorganic fertilizers on physicochemical properties of rice. The experiments were designed in Randomized Complete Block and laid out in split-plots arrangement, replicated four times; The experiment comprised six treatments viz., control (no fertilizer), recommended dose of chemical fertilizers urea 46%N+superphosphate, compost at 12 t ha^{-1}, pellet granules at 60kg ha^{-1}, effective microorganism EM at 15 liters ha^{-1} and combination of urea 46%N+superphosphate + compost. Three varieties namely, Kosti 1, Omgar, and Nerica 4 were used. The laboratory experiment was conducted at Division of Cereal Technology, Food Research Center at Shambat. Results showed that the application of different organic manure and inorganic fertilizer resulted in significantly better parameters. Grain length, length/width ratio, hundred seed weight, crud protein, fiber, fat, ash and carbohydrate were significantly affected by fertilizer, but grain width, teste, moisture percentage and carbohydrate were not significantly affected by fertilizer. Highest percentages of chemical contents were recorded in organic fertilizers and then chemical fertilizers which were identical to control. Most of studied parameters were significantly affected by varieties. The interaction between fertilizer and variety was insignificant in respect of all grain quality characteristics in first season except grain length, but there were significant different in the second season.

Keywords: EM; Compost; Organic Fertilizer; Pellet Granule; Rice; Superphosphate; Urea.

Introduction

Rice (Oryza sativa L.) is one of the predominant food crops of the world, a grain of life for more than 70 per cent of the Asian population and the staple food crop for world's poorest and densely populated regions.

Rice is an extensively consumed cereal crop, which serves as a major source of carbohydrate in human diet (Mohankumar et, al., 2011). Use and management of crop residues, organic and bio fertilizers are becoming an increasingly important aspect of environmentally sound sustainable agriculture (Timsina and Connor, 2001). Long term addition of organic materials to soil results in increased organic matter, crop productivity, soil biological activity (Collins et al., 1992) and also quality of the produce. Application of organic manures for increasing soil fertility has gained importance in recent years due to high cost and adverse impact of chemical fertilizers. The global area under organic production accounts for more than 31 million hectares (Yadav, 2007). Incorporation of organic manures has given a hope to reduce the cost of cultivation and minimize adverse effects of chemical fertilizers. After the achievement of sufficient yield in high yielding varieties, the demand for fine rice is increasing day by day both in home and abroad. The fine grain rice is relatively low yielding but has good demand in the market with relatively higher price. It is also used in preparing special dishes on special occasions.

Moisture content has a marked influence on all aspects of paddy and rice quality and it is essential that paddy be milled at the proper moisture content to obtain the highest head rice yield. Paddy is at its optimum milling potential at moisture

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content of 14% wet weight basis. Grains with high moisture content are too soft to withstand hulling pressure which results in grain breakage and possibly pulverization of the grain. Grain that is too dry becomes brittle and has greater breakage. Moisture content and temperature during the drying process is also critical as it determines whether small fissures and/or full cracks are introduced into the grain structure.

The rice millers prefer varieties with high milling and head rice out-turn, whereas consumers consider quality (Merca and Juliano, 1981). Yields of head rice vary depending on many factors such as variety, grain type, cultural practice, drying, storing and milling conditions (Wasserman and Calderwood, 1972; Witte, 1972; Adair et al., 1973). To attract the consumers' attention, appearance of rice is important which depends on the shininess and chalkiness of the kernel. Size and shape are also important factor to consumer. Preference for grain size and shape vary from one group of consumers to another (Khush et al., 1979). High income group of people in the world prefer long slender grain, whereas, lower income group prefer bold grain (Anonymous, 1997). Higher the imbibitions ratio of rice lower will be the energy content per unit volume or weight of cooked rice, as they will have more water and solid materials (Anonymous, 1999). High volume expansion of cooking is still considered to be the good quality by the working class people who do not care whether the expansion is lengthwise or crosswise. Urban people, on the other hand, prefer the varieties that expand more in length than in breadth (Choudhury, 1979). Fine rice may be graded as export quality rice with normal nutritional quality. Under the above circumstances, the present study was undertaken to analyze and evaluate the chemical and physical properties of some rice varieties affected by organic and inorganic manures.

Materials and Methods:

The grain materials used in the study is consisted of three varieties of Rice (Oryza sativa L.) namely Kosti 1(V1), Omgar (V2), and Nerica 4 (V3) which were grown in the experiment farm of college of Agriculture Studies, Sudan University of Science & Technology, during seasons 2011/2012 & 2012/2013, and they were treated with six treatments **VIZ**: effective microorganism EM (T1); Compost (T2); pellet granules (T3); urea 46%N+superphosphate (T4); urea + superphosphate + compost (T5) and control (without) (T6).

The laboratory experiment was conducted at Division of Cereal Technology, Food Research Center at Shambat.

1. Granules Size: The granules size of rice was recorded using vernier calipers (model: E H B stainless, Hardened, Germany).

2. Grain Dimensions: Using a caliper or photographic enlarger, 20 paddy samples were randomly selected from each replicate and the dimensions were measured to obtain the average length and width of the paddy grains. To obtain the paddy shape, the following equation was used:

$$\text{length to width ratio (L/W)} = \frac{\text{Average paddy length, mm}}{\text{Average paddy width, mm}}$$

Paddy was classified based on International Organization for Standardization (ISO) for paddy.

3. Physico-Chemical Analysis: Physico-chemical analyses were carried out according to methods described in AACC (2000).The moisture content at 105^{o}C/12h, Crude protein was determined by the Kajeldhal's method (Nx5.95), as well as ash content at 550^{o}c/5h, crude fat in Soxhlet apparatus (solvent ether) and crude fiber was measured according to method given in above reference.

Available carbohydrates were calculated by subtracting the sum of fat, protein, fiber and ash as a percentage from 100 as described by West et, al. (1988).

4. Statistical Analysis: Analysis of variance (ANOVA) was carried out for each character, and subsequently ANOVA was used to determine whether there were any differences in the traits studied among rice accessions. Means were separated by the use of least significant differences (L.S.D) at P≤ 0.05 using Statistix 8 software.

Results and Discussion:

Protein content, fiber, fat, moisture, ash and carbohydrate were significantly affected by fertilizers. Highest percentages of chemical contents were recorded in organic fertilizers and then in chemical fertilizers which were identical to control. The highest protein content was (7.30) found by V1 x EM bio-fertilizer, high mean of fiber contents (5.59) records by V2 x control, fat (1.71) was higher under EM bio fertilizer and it was identical to control and chemical fertilizers (Table 1), ash (1.53); (1.60) record by V1xT3 (Kosti1x pellet granules) in season I and season II respectively. Most of studied parameters were insignificantly affected by varieties except carbohydrate with higher percentage (87.04) record by variety (Kosti 1). The interaction between fertilizers and varieties was significant in chemical contents: carbohydrate, fiber and ash in first season, but moisture, protein and fat were insignificant, while all parameters were significant in second season except the fat. The combination between the two seasons showed no significant differences among all

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studied parameters except moisture content (8.59%) in season one and (8.45%) in season two (table 1). The marked differences between the two seasons might be due to the differences in the climatic conditions. This fact was confirmed by Mahalingam et al., (2013). The means from the analysis of variance in table (2) showed that all the Physical properties (grain length, length/ width ratio and hundred seed weight) were significantly affected by treatment. Higher grain length (8.35cm) was recorded by EM x nerica4 and higher ratio L/w (3.29) was obtained by (Kosti1x pellet granules). Hundred seed weight (2.87g) was found by (urea + superphosphate) which were a higher value (table 2). Penile taste shown that all treatments and varieties take normal taste.

The superior performance of these treatments might also be owing to improvement in physical, chemical and microbiological environment of soil favoring increased availability of plant nutrients. Whereas, sole use of some chemical fertilizer supplied few elements with amount that was not sufficient to improve the quality of rice grain similar results were found by Harhsh et al., (2010). On the other hand, chemica fertilizers reduce the physical properties and microbiological activities of soil. Similar result was reported by Pandey et al. (1999); Hossain et al. (2009) and Hemalatha et al. (2004). They reported that all the sources of organic manures improve the soil fertility, yield and quality of rice.

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Table (1): The means of chemical composition of three Rice varieties affected with organic and inorganic fertilizers.

Varieties	Treatments	Season I		Season II	
		Chemical composition %		Chemical composition %	
		Moisture	Protein	Moisture	Protein
V1	T1	8.63[a]	7.30[a]	8.20[h]	7.14[a]
	T2	8.60[a]	6.23[g]	8.11[i]	6.20[h]
	T3	8.61[a]	6.93[bcd]	7.96[j]	6.74[cdef]
	T4	8.49[a]	7.07[abc]	8.74[a]	7.18[a]
	T5	8.49[a]	6.89[bcd]	8.75[a]	6.81[bcd]
	T6	8.49[a]	6.18[g]	8.69[b]	6.22[h]
V. mean		8.55[A]	6.77[A]	8.41[C]	6.71[A]
V2	T1	8.52[a]	7.17[ab]	8.50[d]	6.83[bcd]
	T2	8.50[a]	6.48[efg]	8.45[e]	6.73[cdef]
	T3	8.50[a]	6.89[bcd]	8.65[b]	6.77[cd]
	T4	8.56[a]	6.80[cde]	8.31[g]	6.78[bcd]
	T5	8.55[a]	6.72[def]	8.50[de]	6.45[fgh]
	T6	8.55[a]	6.16[g]	8.12[i]	6.31[gh]
V. mean		8.53[A]	6.70[A]	8.42[B]	6.64[A]
V3	T1	8.59[a]	7.12[abc]	8.12[i]	7.08[ab]
	T2	8.60[a]	6.38[fg]	8.60[c]	6.47[cdef]
	T3	8.61[a]	7.01[abcd]	8.47[ef]	7.01[abc]
	T4	8.79[a]	6.72[def]	8.69[b]	6.55[defg]
	T5	8.73[a]	6.81[cde]	8.58[c]	6.76[cde]
	T6	8.73[a]	6.33[g]	8.58[c]	6.31[gh]
V. mean		8.67[A]	6.73[A]	8.51[A]	6.70[A]
Season means		8.59[A]	6.73[A]	8.45[B]	6.68[A]
C V%		3.09	3.05	0.26	2.72
SE±		0.22	0.17	0.02	0.15

Means with the same small letter within the same column are not statistically different among treatments.

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Means with the same capital letter within the same column are not statistically different between seasons or varieties.

Cont: Table (1):

Varieties	Treatments	Season I		Season II	
		Chemical composition %		Chemical composition %	
		Fat	Fiber	Fat	Fiber
V1	T1	1.71[a]	4.42[abcd]	1.60[a]	5.14[abcd]
	T2	0.77[efg]	4.78[abcd]	0.78[f]	4.66[bcde]
	T3	1.52[ab]	4.36[abcd]	1.61[a]	4.45[def]
	T4	1.05[cdefg]	3.58[de]	0.89[ef]	2.87[hi]
	T5	0.76[efg]	4.87[abc]	0.87[ef]	5.64[a]
	T6	0.71[fg]	2.75[e]	0.77[f]	2.48[i]
V. mean		1.09[A]	4.13[A]	1.09[A]	4.21[B]
V2	T1	1.39[abc]	4.05[cd]	1.31[abcde]	3.88[efg]
	T2	1.02[cdefg]	4.50[abcd]	1.29[abcde]	3.83[efgh]
	T3	1.37[abc]	3.55[de]	1.37[abcd]	4.13[ef]
	T4	1.04[cdefg]	3.74[cde]	1.44[abc]	3.15[ghi]
	T5	1.09[cdef]	3.71[cde]	1.20[abcdef]	3.77[efgh]
	T6	0.69[g]	5.59[a]	0.78[f]	5.88[a]
V. mean		1.10[A]	4.19[A]	1.23[A]	4.11[B]
V3	T1	1.49[ab]	3.54[de]	1.49[a]	3.57[fgh]
	T2	0.88[defg]	5.45[ab]	0.92[ef]	5.54[ab]
	T3	1.40[abc]	3.96[cde]	1.54[a]	4.53[cdef]
	T4	1.26[bcd]	4.71[abcd]	1.03[cdef]	4.50[def]
	T5	1.13[bcde]	4.26[bcd]	1.08[bcdef]	4.61[bcde]
	T6	0.97[defg]	5.57[a]	0.93[def]	5.47[abc]
V. mean		1.19[A]	4.58[A]	1.17[A]	4.70[A]
Season means		1.13[A]	4.30[A]	1.16[A]	4.34[A]
C V%		21.38	12.53	23.27	13.39
SE±		0.20	0.62	0.22	0.47

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Cont: Table (1):

Varieties	Treatments	Season I		Season II	
		Chemical composition %		Chemical composition %	
		Ash	CHO	Ash	CHO
V1	T1	1.20^{b}	85.37^{e}	1.14^{bcd}	84.99^{j}
	T2	0.87^{efgh}	87.34^{bc}	0.48^{g}	87.87^{bc}
	T3	1.53^{a}	85.65^{de}	1.60^{a}	85.60^{ij}
	T4	0.75^{gh}	87.55^{b}	0.50^{g}	88.56^{b}
	T5	0.88^{defgh}	86.60^{bcde}	0.84^{f}	85.85^{hij}
	T6	0.65^{h}	89.71^{a}	0.91^{ef}	89.62^{a}
V. mean		0.99^{A}	87.04^{A}	0.91^{B}	87.08^{A}
	T1	1.11^{bcde}	86.28^{bcde}	1.01^{cdef}	86.98^{cdefg}
	T2	1.08^{bcde}	86.92^{bcd}	1.01^{cdef}	87.14^{cdef}
	T3	1.11^{bcde}	87.07^{bc}	1.24^{b}	86.49^{fghi}
	T4	0.90^{defgh}	87.53^{b}	0.97^{def}	87.66^{bcd}
	T5	0.94^{bcdefg}	87.54^{b}	1.03^{cdef}	87.55^{bcde}
	T6	0.80^{fgh}	86.76^{bcd}	0.96^{def}	86.08^{ghi}
		0.99^{A}	87.02^{A}	1.04^{A}	86.98^{A}
V3	T1	1.18^{bc}	86.66^{bcde}	1.05^{cde}	86.82^{defgh}
	T2	0.97^{bcdefg}	86.32^{bcde}	0.92^{ef}	86.16^{fghi}
	T3	1.07^{bcdef}	86.55^{bcde}	1.18^{bc}	85.74^{ij}
	T4	1.15^{bcd}	86.17^{cde}	1.06^{bcde}	86.86^{cdfg}
	T5	0.99^{bcdefg}	86.82^{bcd}	0.94^{ef}	86.61^{efghi}
	T6	0.91^{cdefgh}	86.25^{bcde}	0.85^{f}	86.44^{fghi}
V. mean		1.05^{A}	86.46^{B}	0.10^{A}	86.44^{B}
Season means		1.01^{A}	86.84^{A}	0.98^{A}	86.83^{A}
C V%		16.45	0.93	11.26	0.70
SE±		0.14	0.66	0.09	0.50

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Table (2): Physical properties means of three rice varieties affected by organic &inorganic fertilizers.

Varieties	treatments	Season I			Season II		
		Physical properties			Physical properties		
		Grain length (mm)	Grain width (mm)	Grain length/ width ratio*	Grain length (mm)	Grain width (mm)	Grain length/ width ratio*
V1	T1	8.00^{ab}	2.60^{abcde}	3.08	8.20^{a}	2.90^{ab}	2.83
	T2	7.50^{c}	3.00^{a}	2.50	7.00^{defg}	2.30^{de}	3.04
	T3	7.50^{c}	2.20^{de}	3.41	7.30^{cde}	2.30^{de}	3.17
	T4	8.20^{a}	2.50^{bcde}	3.28	7.80^{bc}	2.40^{bcde}	3.25
	T5	8.00^{ab}	2.40^{bcde}	3.33	7.60^{bc}	2.50^{bcde}	3.04
	T6	7.00^{defg}	3.00^{a}	2.33	7.00^{defg}	2.40^{bcde}	2.92
V. mean		7.700^{A}	2.617^{B}	2.988	7.483^{A}	2.467^{B}	3.042
V2	T1	7.30^{bcd}	2.60^{abcde}	2.81	6.60^{gh}	3.00^{a}	2.20
	T2	6.20^{hi}	3.00^{a}	2.07	6.00^{i}	3.00^{a}	2.00
	T3	7.00^{defg}	3.00^{a}	2.33	6.40^{fgh}	2.20^{e}	2.91
	T4	7.00^{defg}	3.00^{a}	2.33	6.20^{hi}	2.80^{abcd}	2.21
	T5	6.50^{fgh}	2.90^{ab}	2.24	6.20^{hi}	3.00^{a}	2.07
	T6	6.00^{i}	2.80^{abcd}	2.14	6.00^{i}	2.40^{bcde}	2.50
V. mean		6.667^{B}	2.883^{A}	2.320	6.233^{B}	2.733^{A}	2.315
V3	T1	8.40^{a}	2.70^{abcde}	3.11	8.30^{a}	2.70^{abcde}	3.07
	T2	7.00^{defg}	2.30^{de}	3.04	7.00^{defg}	2.40^{bcde}	2.92
	T3	7.20^{de}	2.30^{de}	3.13	7.00^{defg}	2.30^{de}	3.04
	T4	8.20^{a}	2.60^{abcde}	3.15	8.10^{ab}	2.80^{abcde}	2.89
	T5	8.00^{ab}	2.60	3.08	8.00^{ab}	2.70^{abcde}	2.96
	T6	7.00^{defg}	2.70^{abcde}	2.59	7.00^{defg}	3.00^{a}	2.33
V. mean		7.63^{A}	2.53^{B}	3.02	7.57^{A}	2.65^{B}	2.87
Season means		7.33^{A}	2.68^{A}	2.78	7.09^{B}	2.62^{A}	2.74
SE±		0.16	0.08	0.11	0.17	0.10	0.11
CV		2.71	9.30	8.50	2.71	9.30	8.50

Means with the same small letter within the same column are not statistically different among treatments.
Means with the same capital letter within the same column are not statistically different between seasons or varieties.
* L/W ratio: Slender Over 3.0 ; Medium 2.1 – 3.0 ; Bold 1.1 – 2.0; Round 1.0 or less.

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Cont table (2): Physical properties means of three rice varieties affected by organic &inorganic fertilizers.

Varieties	treatments	Season I		Season II	
		Physical properties		Physical properties	
		100-seeds weight (g)	Taste**	100-seeds weight (g)	Taste**
V1	T1	2.50^{abc}	4.00	2.91^{a}	5.00
	T2	1.81^{f}	5.00	2.51^{abc}	4.00
	T3	2.31^{cdef}	5.00	2.60^{abc}	4.00
	T4	2.30^{cdef}	4.00	2.34^{cdef}	4.00
	T5	2.40^{bcde}	5.00	2.50^{abc}	4.00
	T6	2.00^{ef}	3.00	2.32^{cdef}	5.00
V. mean		2.22^{B}	4.33	2.53^{B}	4.33
V2	T1	2.10^{def}	4.00	2.43^{bcde}	4.00
	T2	2.06^{ef}	2.00	1.86^{f}	4.00
	T3	1.90^{f}	3.00	2.72^{ab}	3.00
	T4	2.06^{ef}	4.00	2.12^{def}	5.00
	T5	2.06^{ef}	5.00	2.19^{def}	4.00
	T6	1.96^{f}	4.00	1.94^{f}	4.00
V. mean		2.023^{C}	3.67	2.210^{C}	4.00
V3	T1	2.64^{ab}	4.00	2.87^{a}	4.00
	T2	2.34^{cdef}	4.00	2.61^{abc}	5.00
	T3	2.47^{bcd}	5.00	2.70^{ab}	5.00
	T4	2.80^{ab}	4.00	2.80^{ab}	4.00
	T5	2.87^{a}	5.00	2.87^{a}	5.00
	T6	2.22^{cdef}	3.00	2.33^{cdef}	3.00
V. mean		2.56^{A}	4.17	2.70^{A}	4.33
Season means		2.27^{B}	4.06	2.48^{A}	4.22
SE±		0.22	0.10	0.17	0.09
CV		7.51	15.78	7.51	15.78

Means with the same small letter within the same column are not statistically different among treatments.

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Means with the same capital letter within the same column are not statistically different between seasons or varieties.

** 5: Desirable, 3-4: Normal, 2-1: off test.

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