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Nitrogen (N) use efficiency and yield in rice under varying types and rates of N source: chemical fertilizer, livestock manure compost and food waste-livestock manure compost

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Abstract

An optimal use of organic composts derived from animal and food wastes could provide an opportunity to achieve both sustainable crop production and soil quality, and a lot of research has provided the evidence. The nitrogen use efficiencies (NUEs) is a definition to evaluate the interaction between crop and nitrogen (N), and, due to this reason, widely used in agriculture. The current work tried to evaluate NUEs as an indicator of N acquisition capacity and physiological responses of rice grown under varying N levels. To do this, we employed different types and rates of nitrogen source, chemical fertilizer, livestock manure-based compost and food waste and livestock manure-containing compost. Despite of the enhanced rice growth and yield by fertilization, a difference by types and rates of fertilization was not observed. Net photosynthetic rate was significantly higher in the treatments of 90–317 N kg ha^{-1}. The NUE (N uptake efficiency × N utilization efficiency) was the highest in lower N application groups, and sharply reduced with an increase in fertilization rates. In contrast, the nitrogen harvest index (NHI, grain N/total biomass N, kg kg^{-1}) showed higher (0.71–0.76 kg kg^{-1}) in greater N application treatments (≤ 317 N kg ha^{-1}). Accordingly, in terms of NUE, our result suggest that rice may be affordable of the application of less than 300 kg N ha^{-1} (combination with chemical fertilizer and organic compost). Nevertheless, it should be investigated how excess N application affects soil quality, and how long rice plant and soil can accept excess N without an environmental load.

Keywords NUEs, Food waste, Organic compost, Rice

Introduction

An increasing global population has pushed the demand of more food, and thus enhancing crop production including rice is an uprising task, which is globally facing. The conventional farming greatly depending on chemical fertilizer input has been double-sided; yield increase but environmental concerns such as soil degradation, biological diversity, and etc. [4, 21]. Scientific literature refers to differently definition of food loss and food waste; the former is frequently defined as waste materials occurring from post-harvest to pre-consumption by human and animals [11], and the latter indicates food loss occurring at the retail and final consumption [24]. Based on the FAO report, an approximately 32% of all food produced in the world occupied as a loss and waste in 2009 [3, 14]. Organic composts which are derived from animal and food wastes have widely and consistently used in an agricultural sector with extensive purposes such

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as not only the promising crop production as an alternative source but also the improvement of soil quality, carbon sequestration and environmental issues [2, 16, 18]. With more food demand throughout the world, mineral nutrition become the most important factors limiting crop productivity. Of those, nitrogen (N) contributes to crop growth and development due to its position requiring the large amount for crop production. In context of N application, an importance of improved nitrogen use efficiency (NUE) has raised up for few decades, and was proved by the response in upland and paddy rice [9] with minimizing potential losses into the environment [9, 10]. As a measure evaluating the maximum yield per unit of N applied, absorbed or utilized by crop plants, the NUE has been classified with various aspects like agronomic efficiency, physiological efficiency, agro-physiological efficiency, apparent recovery efficiency and utilization efficiency [25, 26]. Rice (*Oryza sativa* L.), which is one of the most consumed food crops, covers 11% of global arable land [19] and occupies more than half of total agricultural land in South Korea [20]. It means that rice paddy might be a great opportunity as a place that the fertilization sources including food waste with an appropriate process could be used to ensure enhanced rice yield and nutrient use efficiency. Ding et al. [7] explained advantages of organic resources as an alternative and/or additive to chemical fertilizer in rice production system, not only yield increase but also improved nitrogen use efficiency (NUE). An advanced N management has been scientifically and practically demonstrated by an optimal rate of chemical fertilizer [5], side-deep application [32], slow-release fertilization [31] and organic compost input [16].

Accordingly, in order to pursue simultaneously both promising yield and enhanced NUE, the development of a practical recipe with an optimal combination of chemical fertilizer and organic composts is required due to wider application of both nutrient sources for rice production. However, based on the law of diminishing return, it is unclear how much both fertilizer sources are the optimal level for suitable rice production. Therefore, an objective of the current work was to determine the effects of additional food waste-livestock manure compost (FW-LMC) fertilization on NUE and yield of rice. To take our goals, we examined growth, photosynthesis, yield and NUE from the Saechucheong cultivar (nationwide cultivated).

Materials and methods

Experimental site and weather information

The experiment was performed at the experimental station of Chungbuk National University (CBNU), Cheongju, South Korea (36°37′25″ N, 127°27′14″ E, 61 m) during growth season (May to October) in 2019. Soil physicochemical properties were overall lower than RDA recommendation except soil texture and pH (Table 1). During an experimental period, the ranges of mean maximum and minimum temperature were 20.0 – 31.7 °C and 9.5 – 24.7 °C, respectively. The rain fall was 1190 mm and the average of relative humidity was 61 – 79% (Table 2).

Table 1 Physicochemical properties of soil used in this study

Property	Unit	Data	Recommendation
Sand	(%)	68.3	–
Silt	(%)	11.0	–
Clay	(%)	20.7	–
Soil texture	USDA	Sandy loam	Loam–Silt loam
Bulk density	Mg m^{-3}	1.35	–
pH	1:5	5.6	5.5–6.5
EC	ds m^{-1}, 1:5	0.3	–
Inorganic-N[+]	mg kg^{-1}	5.6	–
Available P_2O_5	mg kg^{-1}	22	80–120
Organic matter	g kg^{-1}	8.3	20–30
K^+	cmol(+) kg^{-1}	0.2	0.2–0.3
Ca^{2+}	cmol(+) kg^{-1}	3.8	5.0–6.0
Mg^{2+}	cmol(+) kg^{-1}	1.2	1.5–2.0
CEC	cmol(+) kg^{-1}		10–15
Available SiO_2	mg kg^{-1}	83	> 157

[+] Sum of nitrate-N and ammonium-N

Table 2 Weather information during an experimental period

Month	Temperature (°C)		Rainfall (mm)	Relative humidity (%)
	Maximum	Minimum		
May	26.9	13.8	20.3	48
June	28.3	18.5	82.5	64
July	30.3	22.8	204.8	72
August	32.2	23.9	80.5	70
September	27.1	19.1	155.1	72
October	21.6	12.2	84.3	67

Experimental setup

The size of each plot located in the experimental station in CBNU was 16.0 m (width) × 3.6 m (length) and the plots were arranged in a randomized block design with 3 replications. The experimental field was flattened prior to the application of fertilizer sources. The study consisted of nine treatments and the type and rate of fertilization sources was as follows: NF - No N fertilizer; SF – 100% Chemical fertilizer (CF) of standard fertilization; SDF – 100% CF of soil diagnosis fertilization; SDF + LMC_{1-3} – SDF + 100 (1 ton/ha), 150 and 300% livestock manure compost (LMC);

and SDF + FW-LMC$_{1-3}$ − 100, 150 and 300% compost including food waste and livestock manure (FW-LMC). The detailed recipe was described in Table 2. The seeds of rice (*Oryza sativa* L. cv. Saechucheong) after an imbibition for 48 h were grown in a plastic container, and the uniformly growing 20-days-old seedlings were transplanted with a planting density of 12 cm (between hills, 4 plant hill^{-1}) × 20 cm (row). The recommended rates of standard and soil-testing of NPK (urea for N; superphosphate for P; potassium chloride for K) was 90:45:57 and 87:78:28 kg ha^{-1}, respectively, at 3 days before transplanting. Two types of organic fertilizer, livestock manure compost (LMC) and the mixture of processed-food waste and livestock manure compost (FW-LMC) were applied with 10 (100%), 15 (150%) and 30 (300%) Mg ha^{-1} as a basal dose at 15 days before transplanting, and an additional dose of N and K was equivalent to soil-testing recommendation. Nutrient contents and total applied amount were shown in Table 3. Nitrogen was applied with three splits (58% as basal, 22% at tillering, and 22% at panicle initiation), potassium with two splits (70% as basal and 30% at panicle initiation). The rice cultivation practices such as irrigation, insecticides and herbicides followed a rural development administration (RDA, Korea) guide.

Growth, yield and yield components

Similarly grown rice plants were taken from each treatment at tillering for the measurement of tiller and biomass production (dry weight). These samples were oven-dried at 80 °C for further analysis. After harvest, the yield components such as number of panicle (hill^{-1}) and spikelet (panicle^{-1}), ripening rate (%) and 1000-grain weight were measured to estimate yield (unhulled and hulled).

Photosynthetic performance

Fully expanded leaves were selected for photosynthesis parameters, net photosynthetic rate (P_n), transpiration rate (E), stomatal conductance (g_s) and intercellular CO_2 content (C_i) at tillering and heading stages (n = 4). The measurements were performed between 10:00 and 14:00 of a sunny day to minimize an interference of environmental variables such as light intensity (800–1200 μmol m^{-2} s^{-1}) and temperature (25–30 °C).

Concentration of mineral nutrients

The powdered straws and grains (500 mg, DW) were mixed with 5 mL of 368 mmol^{-1} L salicylic acid in 84.7% sulfuric acid (H_2SO_4, v/v) for 24 h and wet-digested at 300 °C for 6 h, followed by the addition of several drops of hydrogen peroxide (H_2O_2). The extract was transferred to a 100 mL volumetric flask and diluted to 100 mL with deionized water for the mineral assays. N was determined using an automatic flow injection analyzer (Bran + Lube, Germany). P was measured using the molybdate-blue colorimetry method (UV-2450, Shimadzu, Japan). The cations, K, Ca, Mg, Fe, Cu, Mn and Zn, were measured using an ICP-OES equipment (INTEGRA XMP, GBC, Australia) according to the manufacturer's manual.

Nitrogen use efficiencies (NUEs)

The NUE was calculated by using the following formulas [15]. NUE, NUpE × NUtE (grain yield/fertilized N); N uptake efficiency (NUpE), acquired N/fertilized N; N

Table 3 Fertilization recipe for each treatment

Treatment	Chemical fertilizer (kg ha^{-1})						Organic compost (Mg ha^{-1})		Input (kg ha^{-1})
	Urea			Super phosphate	KCl		Livestock manure	Food waste-livestock manure	N-P-K
	Basal	Tillering	Heading	Basal	Basal	Heading	Basal	Basal	
NF									0-0-0
SF	50	20	20	45	40	17			90-45-57
SDF	49	19	19	78	20	8			87-78-28
SDF + LMC$_1$	49	19	19	78	20	8	10		219-141-214
SDF + LMC$_2$	49	19	19	78	20	8	15		285-173-307
SDF + LMC$_3$	49	19	19	78	20	8	30		483-267-586
SDF + FW-LMC$_1$	49	19	19	78	20	8		10	317-143-108
SDF + FW-LMC$_2$	49	19	19	78	20	8		15	432-176-148
SDF + FW-LMC$_3$	49	19	19	78	20	8		30	777-273-268

+ LMC (DW-based N, 1.32%; P, 0.63%, K, 1.86%), FW-LMC (DW-based N, 2.30%; P, 0.65%, K, 0.80%)

++ 100% of LMC (N-P-K = 132-63-186 kg/ha), 100% of FW-LMC (N-P-K = 230-65-80 kg/ha) utilization efficiency (NUtE), yield/acquired N (assimilation of plant N to produce grain); Nitrogen harvest index (NHI), grain N accumulation/total N accumulation in aboveground biomass (e.g., grain + straw).

Statistical analysis
Analysis of variance was conducted to test the differences in physiological and agronomic traits of rice using a statistical program (SAS ver. 9.4). Data were analyzed in a randomized block design using one-way ANOVA, and, if $p<0.05$, were subjected to Duncan multiple range test (DMRT) to detect significant differences among the means.

Results
Growth, photosynthesis and mineral nutrients of rice plants
Biomass (dry matter) production, photosynthesis and mineral uptake are major factors to determine rice growth and economic yield. The tillers measured at the tillering stage remarkably increased with mineral supply, whereas the type and rate of fertilization didn't show a significant difference (Fig. 1a). All treatments except SDF + LMC_2 showed significantly better growth (dry weight, g $hill^{-1}$) than the control (NF) (Fig. 1b). The highest biomass was observed in SDF + FW-LMC_2 treatment, which resulted in 41.5 ± 0.7 g $hill^{-1}$, compared to the control (27.1 ± 1.2 g $hill^{-1}$). Photosynthetic parameters including intercellular CO_2 concentration (C_i), net photosynthetic rate (P_n), transpiration rate (E) and stomatal conductance (g_s) were measured at the tillering and heading stages (Fig. 2a–d). The Ci was not differed from the treatments at both growth stages. The P_n was not significant between treatments at the tillering, while at the heading stage, P_n was significantly greater in SF (90 N kg ha^{-1}), SDF + LMC_2 (285 N) and SDF + FW-LMC_1 (317 N), which ranged from 10.6 to 12.3 μmol (CO_2) m^{-2} s^{-1}. The differences in E and g_s, which are an indicator of stomata activity were variable with growth stage and treatments, while SDF + FW-LMC1 (317 N) showed the significantly higher levels compared to the control and other treatments (Fig. 2c, d). Macro nutrients including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) measured from rice straw were significantly differed among the treatments at the harvesting stage (Table 4). In a straw, compost application (T7-9, SDF + FW-LMCs) containing food waste resulted in a higher concentration of TN, P_2O_5, K_2O and MgO compared to the control, while CFs and LMCs treatments rarely contributed nutrient accumulation. On the contrary, an abundance of mineral nutrients except P_2O_5 in a rice grain was not affected by the type and rate of fertilization. The highest P_2O_5 concentration in a grain was observed in SDF + FW-LMC_2, followed by SDF + FW-LMC_1 and SDF + LMC_3.

Yield, yield attributes and NUEs
Chemical fertilizer and/or organic compost application had a significant effect on yield and yield components of rice (Table 5). The highest grain yield (4982 – 6549 kg ha^{-1}, hulled) was observed in all fertilization treatments, which indicated 35% higher compared to the control. The fertilization, regardless of the type and rate of fertilization, greatly contributed an increase in panicles, spikelets and filled grain, while 1000 grain weight was not obvious. Compared to the control, panicle, spikelets and filled grain from all treatments were enhanced by 12, 11 and 6%, respectively. The NUE as an indicator

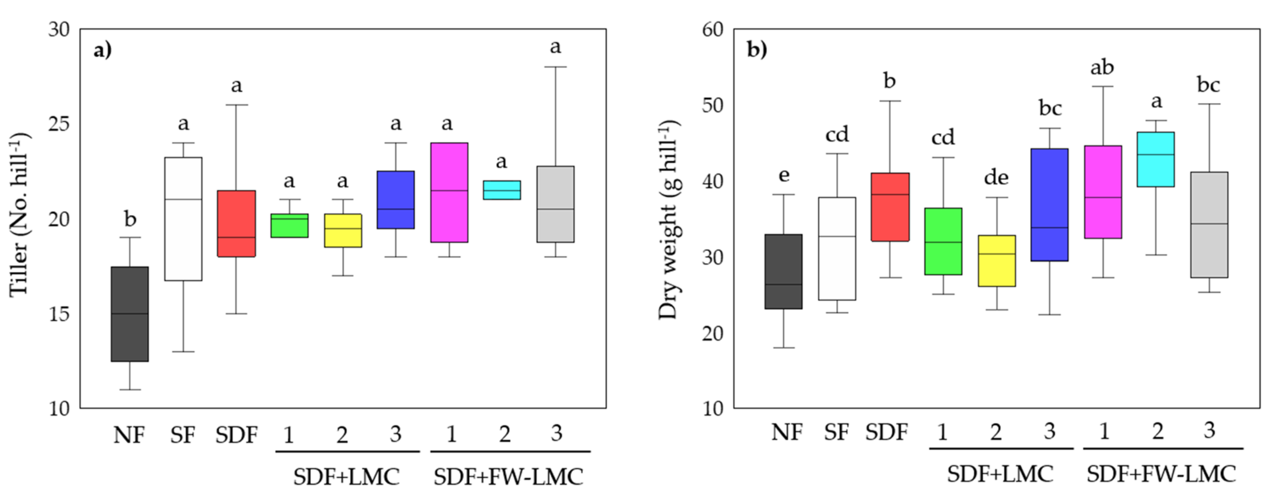

Fig. 1 Comparison of tillers (per hill) and shoot growth and at the tillering stage affected by varying types and rates of fertilization. Rice plants were taken with three replications (3 plants/repeat). Different letters mean a statistical significance at 0.05 (n=4)

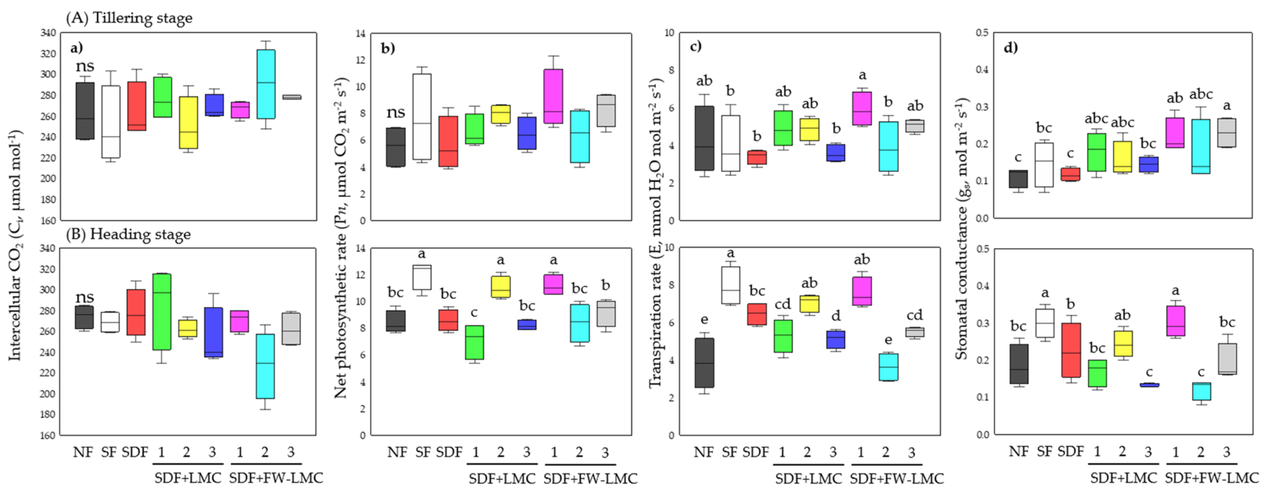

Fig. 2 Photosynthetic performance at tillering and heading stages affected by varying types and rates of fertilization. Rice plants were taken with three replications (2 plants/repeat). Different letters mean a statistical significance at 0.05 (n=4)

Table 4 Mineral nutrients (g kg^{-1}) in straw and grain of rice grown under different types and rates of fertilization at harvesting stage

Treatment	Straw					Grain				
	T-N	P_2O_5	K_2O	CaO	MgO	T-N	P_2O_5	K_2O	CaO	MgO
NF	5.5c	1.8c	23.4c	4.6ns	1.5c	10.6ns	4.9 cd	3.5ns	0.4ns	1.7ns
SF	4.9c	2.1c	28.7b	4.6	1.5c	12.5	5.6bcd	4.8	0.4	2.3
SDF	4.8c	1.8c	28.4b	4.0	1.7c	11.1	4.6d	3.8	0.4	1.8
SDF + LMC_1	5.0c	1.9c	27.5bc	4.5	1.7c	12.6	5.7bc	5.6	0.5	2.7
SDF + LMC_2	4.8c	2.0c	27.2bc	5.1	1.5c	11.5	5.8bcd	4.4	0.4	2.0
SDF + LMC_3	5.5c	1.9c	26.2bc	4.4	1.8c	13.0	6.8ab	4.6	0.4	2.3
SDF + FW-LMC_1	6.2c	1.7c	29.6b	5.0	2.5b	14.2	6.0b	6.1	0.5	2.7
SDF + FW-LMC_2	8.2b	2.1b	29.0b	4.6	2.3b	11.8	7.7a	5.1	0.4	2.3
SDF + FW-LMC_3	10.9a	2.8a	40.5a	4.7	3.7a	13.9	4.6d	3.9	0.4	1.7
F-value	14.78	9.25	9.3	0.32	30.91	2.8	6.08	1.1	0.77	1.23

$^{+}$ NF (No N fertilizer), SF (100% CF – Standard fertilization), SDF (100% CF – Soil diagnosis fertilization), SDF + LMC_{1-3} (SDF + 100, 150 and 300% LMC), SDF + FW-LMC_{1-3} (SDF + 100, 150 and 300% FW + LMC).

Table 5 Yield and yield components of rice affected by different types and rates of fertilization

Treatment	Yield (kg ha^{-1})		Tiller per hill	Grains per panicle	1000 grains weight (g)	Ripening rate (%)
	Unhulled	Hulled				
NF	5860 ± 351b	4336 ± 259b	15.1 ± 0.4d	80.9 ± 3.4d	24.4 ± 0.1 ns	89 ± 3d
SF	7819 ± 802a	5786 ± 593a	16.0 ± 0.6bcd	90.3 ± 2.3abc	25.4 ± 0.6	97 ± 2a
SDF	7917 ± 503a	5858 ± 372a	17.1 ± 0.8abc	88.9 ± 1.1abcd	24.7 ± 0.2	96 ± 1abc
SDF + LMC_1	7392 ± 270a	5470 ± 200a	17.0 ± 0.1abc	84.1 ± 2.5 cd	24.2 ± 1.4	97 ± 2a
SDF + LMC_2	7621 ± 789a	5640 ± 584a	15.8 ± 1.6 cd	90.4 ± 2.6abc	25.1 ± 0.1	97 ± 2ab
SDF + LMC_3	7729 ± 797a	5720 ± 589a	17.4 ± 0.5ab	85.4 ± 9.7bcd	25.5 ± 0.9	93 ± 2bcd
SDF + FW-LMC_1	8387 ± 412a	6207 ± 305a	17.2 ± 0.4abc	95.6 ± 0.7a	24.8 ± 0.9	93 ± 2abc
SDF + FW-LMC_2	8266 ± 531a	6117 ± 393a	16.6 ± 0.8abc	93.7 ± 4.7ab	25.3 ± 0.9	96 ± 3abc
SDF + FW-LMC_3	7947 ± 1,117a	5881 ± 827a	17.9 ± 0.8a	92.8 ± 5.6ab	23.6 ± 0.6	92 ± 3 cd
F-value	3.66	3.66	4.03	3.14	2.16	4.95

$^{+}$ NF (No N fertilizer), SF (100% CF – Standard fertilization), SDF (100% CF – Soil diagnosis fertilization), SDF + LMC_{1-3} (SDF + 100, 150 and 300% LMC), SDF + FW-LMC_{1-3} (SDF + 100, 150 and 300% FW + LMC).

Table 6 Nitrogen use efficiencies (NUEs) of rice grown under different types and rates of fertilization at harvesting stage

Treatment	N input (kg ha^{-1})	NUE (kg kg^{-1})	NUpE (kg kg^{-1})	NUtE (kg kg^{-1})	NHI (kg kg^{-1})
NF	–	–	–	–	–
SF	90	86.9a	1.31b	66a	0.71ab
SDF	87	91.0a	1.58a	58ab	0.71ab
SDF + LMC_1	219	33.8b	0.61c	56ab	0.73ab
SDF + LMC_2	285	26.7b	0.47d	57ab	0.76a
SDF + LMC_3	483	16.0c	0.28e	57ab	0.69b
SDF + FW-LMC_1	317	26.5b	0.59c	45bc	0.72b
SDF + FW-LMC_2	432	19.1c	0.38d	50bc	0.55c
SDF + FW-LMC_3	777	10.2d	0.26e	40c	0.57c
F-value		127.6	104.89	3.78	11.96

+ NUE (nitrogen use efficiency), NUpE (nitrogen uptake efficiency), NUtE (nitrogen utilization efficiency), NHI (nitrogen harvest index)

evaluating an efficacy of fertilization were employed. The NUEs were significantly dependent on the rates of fertilized N (Table 6). The highest NUpE was observed in the SDF (1.58 kg kg^{-1}, the lowest N application), and, this indicated 365% higher compared to fertilization containing organic compost (LMCs, FW-LMCs). The NUtE, as an indicator of yield contribution of absorbed N, was the greatest in the SF (66 kg Nkg^{-1}), followed by SDF and SDF + LMC_{1-3}, and an application of SDF + FW-LMCs showed 60 – 76% of NUtE compared to the SF. By contrast, the NHI was the highest in the SDF-LMC_2 (0.76 kg kg^{-1}), followed by SDF + LMC_1 (0.73). The NUE was clustered with three groups, higher NUE (SF and SDF, less than 100 kg N ha^{-1}), moderate NUE (SDF + LMC_{1-2} and SDF + FW-LMC_1, 200 ~ 400 kg N ha^{-1}), and lower NUE (SDF + LMC_3 and SDF + FW-LMC_{2-3}, more than 400 kg N ha^{-1}).

Discussion

Today's agricultural system heavily depends on fertilization to meet with market demand, although excessive fertilization negatively affects soil environment and crop productivity [6, 30]. It is well documented that organic fertilizers derived from agricultural byproduct, livestock manure, food waste and etc. have positive effects on improving both crop production and soil quality for sustainable agriculture [1]. Thus, the objective of this study was to determine the optimal range of a combined application of chemical fertilizer and organic compost on rice growth, physiology (photosynthesis and nutrient uptake), yield and NUEs. Photosynthesis is a main driver depending on crop production, and positively responds to water and N supply [22]. In terms of the relation between N and photosynthesis, leaf P_n was found higher in both sole chemical N (SF, 90 kg ha^{-1}) and combined application N (SDF + LMC_2, 285 kg ha^{-1} and SDF + FW-LMC_1, 317 kg ha^{-1}) at the heading stage, and showed a similar pattern with an observation by Iqbal et al. [16, 17]. Iqbal et al. [17] reported that higher N from organic compost of total applied N limited photosynthesis, and our result also revealed significant reduction in photosynthesis due to excess application of organic N form. In this investigation, the application of chemical fertilizer and/or organic compost significantly increased tillering, dry weight, yield and yield components and of rice. The current result was in line with previous observations [16, 23, 28]), which pointed out that the mixed application of compost and chemical fertilizer promoted crop growth and yield. However, it was also found from this work that an increasing amount of fertilization did not allow rice plants better growth, and therefore it is suggested that an excess application of compost and chemical fertilizer could heavily accumulate nutrients in the soil. The N requirement during rice production differs due to a variability in the actual acquisition and utilization at the whole plant level including grain, which is affecting physiology and yield. Many evidences that an increasing N application leads to a decrease in NUE due to comparative lower utilization (low grain/total biomass) have been reported [12, 13, 29]. In this work, NUE was greatly fluctuated by the rates of fertilization rather than the type. Indeed, NUE, an integration of NUpE and NUtE, was significantly greater in sole chemical fertilizer groups (SF and SDF) compared to the groups combined with chemical fertilizer and organic compost. The moderate level of N application showed the largest positive influence of total NUE and grain yield compared to lower or higher N supplies [33], and excess N application resulted in markedly reduced NUE despite of yield increase [27]. Despite of lower NUE, our finding indicates that the moderate increase in fertilization (N) leads to higher translocation of N from shoot and root to grain. This result suggests that rice plants may be affordable of more N through efficient N partitioning. Nevertheless, it still needs to answer the fate of the rest of applied N, which is not acquired by rice plant, either soil storage or environmental release (gas emission and/or leaching). In conclusion, the food waste as well as livestock manure is a valuable nutrient source to ensure sustainable productivity of important food crops. The recommended fertilization is mainly focused on an availability of plants with a marginal consideration of soil-holding capacity (buffering). Considering both an over-production of livestock manure and food waste and their final destination, agricultural lands are an almost unique place to accept both wasteful sources. In this work, we tried to find a possibility of livestock manure- and/or food waste-containing composts as an alternative comparable to chemical fertilizers. From this work, the result showed that less than 300 kg N ha^{-1}, which is combined with chemical fertilizer and organic compost, could ensure suitable growth, yield and NUE in rice production system. However, we strongly suggest to further investigate how excess fertilization, a combination of chemical and organic compost, affects soil physical/chemical/biological properties, and how long rice plant and soil can accept excess N without environmental issues.

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Author contributions
JS, T-K O and Y-S S contributed to the study conception and design. Material preparation, data collection and analysis were performed by JS and WK. The first draft of the manuscript was written by JS, and T-KO and Y-SS commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
The data that support the findings of this study are available from the corresponding author, [J. Sung], upon reasonable request.

Declarations

Ethics approval and consent to participate
The manuscript does not have potential conflicts of interest. The research does not involve human participants or animals

Consent for publication
Not applicable.

Competing interests
The authors have no relevant financial or non-financial interests to disclose.

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