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# Effect Of Animal And Plant Organic Fertilizers On Growth And Yield Of Rice In Tana Delta, Kenya

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***Abstract***
*Rice is the 3rd most consumed cereal in Kenya while production is merely 20% of the demand making the country a net importer of the commodity. With increased global concern on healthy foods, producing more rice to contribute to achieving food secure nation while conforming to environmental sustainability remains a subject of concern in the country. In this case, good agricultural practices are needed to strike the balance. This study was carried out during rice growing season (February – June, 2024) to investigate the effect of basal organic fertilizers; Rich Farm (RF), Han Daebak (BK) and Han Yoobak (MK) on growth and yield of AT054 and Komboka rice varieties in Tana Delta Irrigation Project-Rice (TDIP-R) Scheme during the trial Phase undertaken by Agri All Africa (AAA) in preparation for a Public Private Partnership (PPP) project programme. The study was conducted in a Randomized Complete Block Design (RCBD). Rich Farm (RF) at 200 Kg/Ha, Han Daebak (BK) at 200 Kg/Ha and Han Yoobak (MK) at 200 Kg/Ha were applied as basal fertilizers. Conventional fertilizers (200 Kg/Ha DAP + 120 Kg/Ha MOP) was applied as the positive standard check (CF). Data collected was subjected to analysis of variance (ANOVA). The basal application of Rich Farm, Han Daebak and Han Yoobak organic fertilizers had significant positive effects on grain yield. Among the tested basal fertilizers, Rich Farm performed better at 4.9 and 5.3 ton/ha, followed by Han Yoobak at 4.7 and 4.1 ton/ha and Han Daebak at 4.3 and 3.9 ton/ha in AT054 and Komboka variety, respectively. Therefore, Rich Farm and Han Yoobak can be recommended as basal organic fertilizers in both AT054 and Komboka varieties, while Han Daebak can be used in AT054 variety for rice production. Further studies are of need to investigate the effects on these organic fertilizers on the soil properties of the area, as well as evaluating the optimal rates for higher rice production.*
***Keywords:*** *Rice production, Environmental sustainability, Organic fertilizers, Grain yield, Kenya*

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## I. Introduction

In Kenya, among the cereal crops, rice (*Oryza sativa*) is ranked the third cereal crop after maize and wheat in their order of importance[1]. Rice crop in the country is produced mainly in small scales for food and cash[2]. Nearly 80% and 20% of rice produced in the country is under government established irrigation schemes and rain-fed conditions, respectively[3]. The key areas of rice production include Kirinyaga County (Mwea), Busia County (Bunyala), Tana River County (Tana Delta, Bura, Hola), Kwale County (Msambweni), Kisumu County (Ahero, West Kano), Migori County (Lower Kuja, Kuria)[4].

Rice plays a crucial role in ensuring food security and providing labour with approximately 300,000 farmers employing Kenyans to earn their livelihood of the crop's production[4]. Rice by-products (rice straw, hulls) are utilized as animal feeds and substrate for rising mushrooms production enterprise while husks are used as fuel and filler materials[5]. By 2019, reports indicated that rice consumption in the country continues to rise swiftly at an estimated 11% per annum[6], due to population growth, urbanization, change in user likings as well as economic progress[7].

Between 2020 and 2023, Kenya's rice production rose from 164,102.3 MT to 207,805.5 MT, primarily due to an expansion in the area cultivated[8]. Concurrently, rice consumption grew from 1,129,000 MT in 2022 to 1,175,000 MT in 2023[8]. This increase in consumption necessitated a rise in rice imports, which escalated from 548,986.2 MT in 2020 to 850,130.2 MT in 2023, with a total value of KSh. 26.34 and 54.78 Billion, respectively[8]. Furthermore, the consumption of rice in the nation is predicted to upsurge to over 1,292,000 MT per year by the year 2030[9]. This implies that Kenya will remain a net importer of rice if production of the crop is not enhanced.

In that matter, Kenyan government has prioritized rice production as a strategic and crucial income generating crop to meeting its most significant agricultural policy concern – achieving food security and employment while conforming to environmental sustainability[10]. This is evident in existing government policies such as Vision 2030, The Big Four Agenda, National Food Nutrition and Security, revised National Rice Development Strategy-II (2020 – 2030) policy among others. To contribute to this, the current study explores the use of different organic fertilizers in enhancing sustainable rice production. Therefore, keeping in sight the importance of this approach, the current study was conducted to improve and maximize the productivity of AT054 and Komboka rice varieties under Tana Delta Irrigation Project-Rice (TDIP-R) scheme by studying the effects of basal organic fertilizers namely; Rich Farm (8-3-3-CaO), Han Daebak (3.8-2-1.2) and Han Yoobak (4-2-1) on their yield. The test varieties have been recently introduced in the region and are increasingly gaining consumer preference, hence the need to explore possibilities of maximize their yield and economic potential.

## II. Materials And Methods

**Description of the study area**

The study treatments were set up in Tana Delta Irrigation Project-Rice (TDIP-R) scheme. Geographically, the study area is located at between latitude: 2° 9′ 40.428″ – 2° 12′ 4.28″ S and longitude: 40° 9′ 16.236″ – 40° 11′ 40.236″ E at the elevation of above 20 m from sea level, between Kulesa and Sailoni Villages of Tana River County[11]. The region exhibits semi-arid conditions receiving low to unreliable mean annual rainfall of 300 – 900 mm, mean air temperature of 30 °C and mean relative humidity of 85%[12]. Initially, the soils of the study area belonged to Fluvisoils (eutric and vertic) – black cotton soils with clay, loam and alluvial deposits, moderate to high fertility[13]. However, owing to the meandering and change of course and frequent deposits over the years from the Tana River floods, the soils are often distinguished to be yellowing-brown sands and clay deposits rich in Micas[12].

**Preparation of the land**

Land preparation for the study plots involved plowing/tillage, puddling and levelling. Land tillage was done mechanically using tractor-drawn disc plow when the soil was dry. Main plots were measured and marked with wooden pegs. The experimental plots were manually bunded with in-lets and out-lets for easy water movement. Water was introduced and plots levelled by cutting out high spots and filling in the low spots using hoes, spades and rakes. The plots were uniformly puddled to create soil conditions that facilitated transplanting of seedlings and improve water retaining capacity of the soil. The process was repeated to achieve uniformly level plots. Thereafter, the bunds were reinforced and compacted to hold irrigation water in position.

**Description of study design**

The study was conducted for one season during Long rain season of February to June, 2024. The four treatments were each randomly allocated in 100 m$^2$ (10 m x 10 m) plots established in a Randomized Complete Block Design (RCBD) replicated three times (Plate 2.1). This translated to a size of 300 m$^2$ per treatment, 1,200m$^2$ per variety and a total of 2,400m$^2$ under the study for the two varieties. Individual treatments were separated by 1 m distance, and a 2 m distance border was put between the two varieties.

| BLK | AT054 VARIETY | | | | BORDER | KOMBOKA VARIETY | | | | BLK |
|---|---|---|---|---|---|---|---|---|---|---|
| BLK1 | AT-BK | AT-CP | AT-MK | AT-RF | | K-BK | K-CP | K-RF | K-MK | BLK1 |
| BLK2 | AT-CP | ATMK | AT-RF | AT-BK | | K-CP | K-RF | K-MK | K-BK | BLK2 |
| BLK3 | AT-RF | AT-BK | AT-CP | AT-MK | | K-BK | K-CP | K-MK | K-RF | BLK3 |

Plate 2.1: Arrangement of the study treatments in the field in a Randomized Complete Block Design (RCBD). BLK – Block, AT – AT054 variety, K – Komboka variety, RF – Rich Farm, BK – Han Daebak, MK – Han Yoobak, CP – Conventional Products.

**Establishment of the crop**

The study was carried out with two rice varieties; AT054 and Komboka which are suitable for the area, moderate to rice blast disease and have high yielding potential. The nurseries for AT054 and Komboka rice varieties were established adjacent to the main experimental plots. Nursery beds measuring 10 m by and 1.5 m in were prepared. The beds were elevated between 4 to 6 cm above the ground surface and leveled appropriately.

For each variety, seeds at the rate of 50 Kg/ha were soaked for 24 hours and then incubated in polythene bags for an additional 48 hours. The pre-germinated seeds were evenly distributed on the puddled nursery beds during the evening hours. The nurseries were maintained with sufficient moisture and crop protection measures. After a period of 21 days, the seedlings were ready for transplanting. Prior to uprooting healthy seedlings, the nurseries were watered, after which the seedling were uprooted, washed in running water and transplanted in well-leveled main plots. The seedlings were hand-transplanted into the main plots, utilizing marked transplanting lines. Each hill was transplanted with 2 – 3 seedlings at a depth of 3 cm and a spacing of 20 cm by 20 cm. Any gaps were filled with seedlings within 7 – 10 days post-transplanting, utilizing surplus seedlings from the nurseries.

**Description of treatment application**

The full doses of the three test organic fertilizers from Han Bio Company Limited, Korea, namely; Rich Farm (RF) at 200 Kg/Ha, Han Daebak (BK) at 200 Kg/Ha and Han Yoobak (MK) at 200 Kg/Ha were applied as basal fertilizers and incorporated into their respective plots before transplanting. A blend of commercially available fertilizers (200 Kg/Ha DAP + 120 Kg/Ha MOP) was applied as the standard check (CF). Based on the plot size (100 $m^2$), these rates of application were calculated as 2 Kg/100 $m^2$ of RF, 2 Kg/100 $m^2$ of BK, 2 Kg/100 $m^2$ of MK and 2 Kg/100 $m^2$ DAP + 1.2 Kg/100 $m^2$ MOP of CF and applied in their respective plots. The description of treatments' composition is presented in Annex I.

**Management of the crop**

The 1$^{st}$ top dressing of crop with 100 Kg/Ha Urea (46% N) + 40 Kg/Ha Ammonium sulphate AS (21% N, 24% S) was done at 10 days after transplanting (DAT) followed by 2$^{nd}$ top dressing with 100 Kg/Ha Urea at 40 DAT. The 1$^{st}$ and 2$^{nd}$ foliar application with 2.5 L/Ha YaraVita Crop Boost (44% $P_2O_5$, 7.5% $K_2O$, 6.6% MgO, 4.6% Zn) and 1 L/Ha Green Super Foliar (24:24:20 + TE + Sea Weed Extracts, 0.2% B, 0.6% Mg, 0.4% Zn, 0.9% Cu, 1.2% Mn + Fe) was done at middle tillering (21 DAT) and booting/panicle initiation (45 DAT) stages of crop development, respectively, in order to supplement the crop nutrition. Other different intercultural operations including irrigation, pest and weed control were performed as and when required. In this case, flush irrigation was done at initial stages after transplanting followed by permanent flooding (15 – 20 cm depth) to booting/panicle initiation (PI). Thereafter a thin layer (5 – 10 cm depth) of water was kept in plots till grain filling stage. Water was removed from plots to facilitate land drying for in readiness for harvesting. Early insect pest infestation and disease infection within trial plots were timely managed by 0.3 L/Ha Thunder 145 OD (Imidacloprid 100g/L + Betacyfluthrin 45g/L) and 0.75 L/Ha Twiga-Epox 250 SC (Epoxiconazole 250g/L), while late insect pest infestation and disease infection were managed by 1 L/Ha Escort 19 EC (Emamectin benzoate 19g/L) and 0.5 L/Ha Stamina 500 SC (Azoxystrobin 200g/L + Tebuconazole 300g/L), respectively. Weeds were management by 3.5 L/ha Topshot 60 OD (Cyhalofop-butyl 500g/L + Penoxsulam 100g/L) selective herbicide. Additionally, manual weeding was utilized to supplement selective herbicide weed management during reproductive stages of the crop development. Based on the plot size, the rates were scaled down and manually applied by use of knapsack sprayer.

**Collection of data**

Data collection followed a simple random technique[14]. The parameters of interest were collected within 1 $m^2$ unit area from each plot. Plant attributes, namely; plant stand, plant height, number of tillers, tillering ability and plant vigour were observed. Afterward, fertile tillers, panicle length, panicle exsertion length, total number of spikelets, filled spikelets, non-filled spikelets, affected spikelets, grain length and grain width were assessed as yield contributing characteristics. Finally, dry grain (14% MC) yield weights were assessed and recorded for analysis. Tillering ability and plant vigour were rated based on the scales (Annex II) described by[15]. Detailed data collection procedure for each parameter is described in Annex III. Data was collected on weekly basis.

**Statistical analysis of data**

All the data from the study were processed by GenStat 15$^{th}$ Edition statistical package. The data were analyzed using analysis of variance (ANOVA) according the Randomized Complete Block Design procedures. Treatment averages were compared by Fisher's Protected Least Significant Difference Multiple Comparison test at $p<0.05$ level of significance.

## III. Results

**Plant height (cm)**

Table 3.1 indicates that Rich Farm, Han Daebak, Han Yoobak and the standard check, Conventional fertilizers had significant effects on the growth of AT054 and Komboka varieties as indicated by variations in plant height at different crop growth stages. At heading stage of crop development, the highest value for plant height (96.5 cm) was observed in plots subjected to Han Daebak in Komboka variety which was statistically on par with those of Conventional fertilizers (94.9 cm) in Komboka variety, but statistically different from the rest of the treatments. This was followed by the application of Han Yoobak (93.4 cm) in Komboka variety. The shortest plant height of 87.4 cm was found in Han Yoobak in AT054 variety which was statistically on par with those of Conventional fertilizers (89.2 cm) in AT054 variety, Han Daebak (89.3 cm) in AT054 variety, but statistically different from Rich Farm (90.0 cm) in AT054 and Rich Farm (90.6 cm) in AT054 variety.

**Table 3.1 Effect of different organics fertilizers on plant height (cm) of two rice varieties**

| | | Tillering | | | | Tillering/PI | PI | PI/Booting | Booting | Heading |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **Regime** | **4 DAT** | **11 DAT** | **18 DAT** | **25 DAT** | **32 DAT** | **39 DAT** | **46 DAT** | **55 DAT** | **62 DAT** |
| AT054 | RF | $49.5_{d}$ | $51.5_{b}$ | $63.4_{c}$ | $59.1_{bc}$ | $67.4_{cd}$ | $74.0_{cd}$ | $75.7_{b}$ | $83.7_{bc}$ | $90.0_{b}$ |
| | BK | $44.7_{c}$ | $50.4_{b}$ | $64.5_{c}$ | $64.4_{d}$ | $69.2_{d}$ | $74.8_{d}$ | $76.3_{d}$ | $82.9_{abc}$ | $89.3_{ab}$ |
| | MK | $48.6_{d}$ | $53.0_{b}$ | $59.4_{b}$ | $61.0_{cd}$ | $68.1_{d}$ | $71.9_{bcd}$ | $74.9_{ab}$ | $80.3_{a}$ | $87.4_{a}$ |
| | CF | $52.6_{e}$ | $52.4_{b}$ | $62.8_{c}$ | $61.6_{cd}$ | $70.4_{d}$ | $74.7_{d}$ | $74.7_{ab}$ | $82.2_{ab}$ | $89.2_{ab}$ |
| Komboka | RF | $26.4_{a}$ | $44.1_{a}$ | $44.8_{a}$ | $50.5_{a}$ | $58.3_{ab}$ | $68.8_{b}$ | $73.3_{ab}$ | $91.1_{d}$ | $90.6_{b}$ |
| | BK | $30.8_{b}$ | $43.2_{a}$ | $46.7_{a}$ | $52.2_{a}$ | $59.5_{b}$ | $65.2_{a}$ | $71.9_{a}$ | $83.9_{bc}$ | $96.5_{d}$ |
| | MK | $31.0_{b}$ | $45.6_{a}$ | $46.5_{a}$ | $50.2_{a}$ | $55.0_{a}$ | $71.3_{bc}$ | $71.7_{a}$ | $85.5_{c}$ | $93.4_{c}$ |
| | CF | $27.4_{a}$ | $44.1_{a}$ | $46.9_{a}$ | $56.0_{b}$ | $64.3_{c}$ | $74.3_{cd}$ | $76.1_{b}$ | $89.8_{d}$ | $94.9_{cd}$ |
| **LSD** | | **2.9** | **2.7** | **3.2** | **3.3** | **3.5** | **3.3** | **3.3** | **2.9** | **2.3** |
| **CV (%)** | | **3.5** | **4.7** | **2.4** | **2.4** | **3.2** | **1.5** | **0.1** | **0.9** | **0.3** |

Data are means of three replicates. Means with letter(s) in common in the same column are not significantly different based on Fisher's Protected LSD Multiple Comparisons Test at p<0.05 significance level. RF – Rich Farm, BK – Han Daebak, MK – Han Yoobak, CF – Conventional Fertilizers, PI – Panicle initiation, DAT – Days after transplanting.

**Number of tillers per hill**

Application of basal fertilizers (Table 3.2) the test fertilizers; had significant effects on the number of tillers/hill produced in AT054 and Komboka varieties, particularly during the tillering stages. The number of tillers/hill recorded ranged from 2.5 – 3.4 tillers/hill at early tillering stages and 15.0=21.7 tillers/hill at maximum tillering stages of crop development. From panicle initiation (PI) to heading stage, there was less effects of treatments on the number of tillers/hill produced in both the varieties. At heading stage, the highest tillers number per hill (20.3) was recorded from Rich Farm application in AT054 variety. However, there was no significant difference in tillering among the other treatments.

**Table 3.2 Effect of different organics fertilizers on tillers number/hill of two test rice varieties**

| | | Tillering | | | | Tillering/PI | PI | PI/Booting | Booting | Heading |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **Regime** | **4 DAT** | **11 DAT** | **18 DAT** | **25 DAT** | **32 DAT** | **39 DAT** | **46 DAT** | **55 DAT** | **62 DAT** |
| AT054 | RF | $2.6_{ab}$ | $3.0_{a}$ | $11.3_{abc}$ | $16.7_{abc}$ | $15.3_{a}$ | $20.2_{d}$ | $20.9_{b}$ | $19.2_{ab}$ | $20.3_{a}$ |
| | BK | $2.7_{ab}$ | $3.4_{a}$ | $9.3_{a}$ | $15.8_{ab}$ | $15.0_{a}$ | $17.1_{abc}$ | $18.5_{a}$ | $19.2_{ab}$ | $19.2_{a}$ |
| | MK | $2.8_{ab}$ | $3.2_{a}$ | $12.3_{bc}$ | $14.9_{a}$ | $16.9_{ab}$ | $18.7_{bcd}$ | $20.5_{b}$ | $18.4_{a}$ | $18.3_{a}$ |
| | CF | $2.5_{a}$ | $3.6_{a}$ | $10.9_{ab}$ | $18.7_{bcd}$ | $15.4_{a}$ | $20.1_{cd}$ | $20.3_{ab}$ | $18.9_{a}$ | $19.7_{a}$ |
| Komboka | RF | $3.1_{bc}$ | $8.7_{bc}$ | $15.4_{de}$ | $20.0_{d}$ | $21.7_{c}$ | $17.0_{ab}$ | $19.8_{ab}$ | $20.6_{ab}$ | $20.1_{a}$ |
| | BK | $3.4_{c}$ | $8.4_{b}$ | $13.2_{cd}$ | $19.3_{cd}$ | $16.8_{ab}$ | $15.3_{a}$ | $19.8_{ab}$ | $21.4_{b}$ | $19.9_{a}$ |
| | MK | $3.2_{bc}$ | $9.2_{bc}$ | $15.8_{e}$ | $17.1_{abcd}$ | $21.4_{c}$ | $16.2_{ab}$ | $19.1_{ab}$ | $20.5_{ab}$ | $19.1_{a}$ |
| | CF | $3.4_{c}$ | $9.9_{c}$ | $17.5_{e}$ | $18.5_{bcd}$ | $19.9_{bc}$ | $15.7_{a}$ | $19.8_{ab}$ | $20.3_{ab}$ | $20.2_{a}$ |
| **LSD** | | **0.6** | **1.4** | **2.3** | **3.0** | **3.1** | **3.0** | **2.0** | **2.4** | **2.7** |
| **CV (%)** | | **1.9** | **3.7** | **7.2** | **2.9** | **6.6** | **6.2** | **0.6** | **5.0** | **0.9** |

Data are means of three replicates. Means with letter(s) in common in the same column are not significantly different based on Fisher's Protected LSD Multiple Comparisons Test at p<0.05 significance level. RF – Rich Farm, BK – Han Daebak, MK – Han Yoobak, CF – Conventional Fertilizers, PI – Panicle initiation, DAT – Days after transplanting.

**Number of tillers per unit area**

As indicated in Table 3.3 with a plant density of 25 hills/$m^2$, the number of tillers/hills that at heading stage were 507.5, 505.0, 502.9, 497.9, 492.9, 479.8, 477.7 and 458.5 tillers/$m^2$ producedunder Rich Farm in AT054, Conventional fertilizers in Komboka, Rich Farm in Komboka, Han Daebak in Komboka, Conventional fertilizers in AT054, Han Daebak in AT054, Han Yoobak in Komboka and Han Yoobak in AT054 variety, in their order of decreasing numbers, respectively.

**Table 3.3 Effect of different organics fertilizers on tillers/m² of two rice varieties**

| | | | Tillering | | | | Tillering/PI | PI | PI/Booting | Booting | Heading |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **Regime** | **Hills/m²** | **4 DAT** | **11 DAT** | **18 DAT** | **25 DAT** | **32 DAT** | **39 DAT** | **46 DAT** | **55 DAT** | **62 DAT** |
| AT054 | RF | 25.0 | $66.0_{ab}$ | $74.4_{a}$ | $281.3_{abc}$ | $417.7_{abc}$ | $381.9_{a}$ | $506.0_{d}$ | $522.1_{b}$ | $480.0_{ab}$ | $507.5_{a}$ |
| | BK | 25.0 | $67.7_{ab}$ | $85.6_{a}$ | $233.5_{a}$ | $395.8_{ab}$ | $374.4_{a}$ | $427.5_{abc}$ | $462.7_{a}$ | $479.0_{ab}$ | $479.8_{a}$ |
| | MK | 25.0 | $69.4_{ab}$ | $80.4_{a}$ | $308.3_{bc}$ | $373.1_{a}$ | $421.5_{ab}$ | $466.9_{bcd}$ | $512.3_{b}$ | $459.8_{a}$ | $458.5_{a}$ |
| | CF | 25.0 | $62.7_{a}$ | $89.4_{a}$ | $271.3_{ab}$ | $467.3_{bcd}$ | $385.0_{a}$ | $501.9_{cd}$ | $508.3_{ab}$ | $473.1_{a}$ | $492.9_{a}$ |
| Komboka | RF | 25.0 | $78.5_{bc}$ | $217.9_{bc}$ | $386.0_{de}$ | $499.8_{d}$ | $541.9_{c}$ | $425.6_{ab}$ | $494.6_{ab}$ | $515.0_{ab}$ | $502.9_{a}$ |
| | BK | 25.0 | $85.6_{c}$ | $211.0_{b}$ | $330.4_{cd}$ | $481.9_{cd}$ | $421.0_{ab}$ | $382.9_{a}$ | $495.8_{ab}$ | $534.8_{b}$ | $497.9_{a}$ |
| | MK | 25.0 | $80.8_{bc}$ | $230.6_{bc}$ | $394.0_{e}$ | $427.5_{abcd}$ | $535.0_{c}$ | $406.0_{ab}$ | $476.7_{ab}$ | $511.9_{ab}$ | $477.7_{a}$ |
| | CF | 25.0 | $85.6_{c}$ | $248.8_{c}$ | $438.5_{e}$ | $461.5_{bcd}$ | $496.7_{bc}$ | $392.1_{a}$ | $495.8_{ab}$ | $508.5_{ab}$ | $505.0_{a}$ |
| **LSD** | | | **14.8** | **35.2** | **56.6** | **74.3** | **78.5** | **74.6** | **49.2** | **61.2** | **66.4** |
| **CV (%)** | | | **1.9** | **3.7** | **7.2** | **2.9** | **6.6** | **6.2** | **0.6** | **5.0** | **0.9** |

Data are means of three replicates. Means with letter(s) in common in the same column are not significantly different based on Fisher's Protected LSD Multiple Comparisons Test at $p<0.05$ significance level. RF – Rich Farm, BK – Han Daebak, MK – Han Yoobak, CF – Conventional Fertilizers, PI – Panicle initiation, DAT – Days after transplanting.

**Tillering ability**

The tillering ability (Table 3.4) was rated on a scale of 1 – 9, with 1 as very high while 9 as very low tillering ability. The tillering ability at different stages of crop development varied significantly with the basal application of Rich Farm, Han Daebak, Han Yoobak and the standard check, Conventional fertilizers. At heading stage of crop development, basal application of Conventional fertilizers (2.7) in Komboka variety resulted in superior tillering ability which was statistically similar to that of Han Yoobak (3.3) in Komboka variety, but statistically different from other treatments. Tillering ability obtained from Rich Farm (3.8) in Komboka variety, Han Daebak (3.8) in variety, Rich Farm (3.8) in AT054 variety, Han Daebak (4.5) in AT054 variety, Han Yoobak (4.5) in AT054 variety and Conventional fertilizers (4.5) in AT054 were not different.

**Table 3.4 Effect of different organics fertilizers on tillering ability/hill of two rice varieties**

| | | Tillering | | | | Tillering/PI | PI | PI/Booting | Booting | Heading |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **Regime** | **4 DAT** | **11 DAT** | **18 DAT** | **25 DAT** | **32 DAT** | **39 DAT** | **46 DAT** | **55 DAT** | **62 DAT** |
| AT054 | RF | $9.0_{a}$ | $9.0_{b}$ | $5.3_{b}$ | $4.5_{ab}$ | $4.8_{b}$ | $4.0_{a}$ | $4.0_{ab}$ | $4.5_{b}$ | $3.8_{bc}$ |
| | BK | $9.0_{a}$ | $8.7_{b}$ | $6.2_{c}$ | $4.7_{b}$ | $4.8_{b}$ | $4.5_{ab}$ | $4.8_{b}$ | $4.3_{ab}$ | $4.5_{c}$ |
| | MK | $8.8_{a}$ | $9.0_{b}$ | $5.5_{bc}$ | $5.0_{b}$ | $4.8_{b}$ | $4.0_{a}$ | $3.7_{a}$ | $4.3_{ab}$ | $4.5_{c}$ |
| | CF | $9.0_{a}$ | $8.7_{b}$ | $5.5_{bc}$ | $4.3_{ab}$ | $4.7_{b}$ | $4.2_{a}$ | $3.8_{a}$ | $4.3_{ab}$ | $4.5_{c}$ |
| Komboka | RF | $8.8_{a}$ | $6.2_{a}$ | $4.8_{ab}$ | $3.8_{a}$ | $3.2_{a}$ | $5.5_{b}$ | $4.0_{ab}$ | $3.5_{a}$ | $3.8_{bc}$ |
| | BK | $8.8_{a}$ | $6.7_{a}$ | $5.5_{bc}$ | $4.5_{ab}$ | $4.5_{b}$ | $4.8_{ab}$ | $4.2_{ab}$ | $3.5_{a}$ | $3.8_{bc}$ |
| | MK | $9.0_{a}$ | $6.3_{a}$ | $4.8_{ab}$ | $4.7_{b}$ | $3.5_{a}$ | $5.3_{b}$ | $4.2_{ab}$ | $3.8_{ab}$ | $3.3_{ab}$ |
| | CF | $8.7_{a}$ | $6.2_{a}$ | $4.5_{a}$ | $4.3_{ab}$ | $4.0_{ab}$ | $5.0_{ab}$ | $4.0_{ab}$ | $3.8_{ab}$ | $2.7_{a}$ |
| **LSD** | | **0.4** | **0.6** | **0.7** | **0.8** | **0.9** | **1.0** | **0.8** | **0.9** | **1.1** |
| **CV (%)** | | **0.8** | **1.7** | **3.6** | **2.9** | **6.7** | **2.0** | **0.9** | **5.0** | **3.2** |

Data are means of three replicates. Means with letter(s) in common in the same column are not significantly different based on Fisher's Protected LSD Multiple Comparisons Test at $p<0.05$ significance level. RF – Rich Farm, BK – Han Daebak, MK – Han Yoobak, CF – Conventional Fertilizers, PI – Panicle initiation, DAT – Days after transplanting, Tillering Ability Scale: 1 – Very high, 3 – Good, 5 – Medium, 7 – Low, 9 – Very low.

**Plant vigour**

Plant vigour (Table 3.5) rated on a scale of 1 – 9 with 1 as extra vigorous while 9 as very weak showed significant effect from early tillering to panicle initiation (PI) stages between the varieties. At PI stage, with exception of Rich Farm (6.0) in AT054, basal application of the standard check, Conventional fertilizers (4.2) in Komboka recorded superior plant vigour which was statistically similar to the other treatments in both varieties. During the booting and heading stages of crop development, all the test basal fertilizers and the standard check were not significantly different in plant vigour.

**Table 3.5 Effect of different organics fertilizers on plant vigour/hill of two rice varieties**

| | | Tillering | | | | Tillering/PI | PI | PI/Booting | Booting | Heading |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **Regime** | **4 DAT** | **11 DAT** | **18 DAT** | **25 DAT** | **32 DAT** | **39 DAT** | **46 DAT** | **55 DAT** | **62 DAT** |
| AT054 | RF | $6.3_{cd}$ | $5.0_{a}$ | $5.3_{ab}$ | $4.0_{a}$ | $4.0_{a}$ | $6.0_{b}$ | $2.0_{a}$ | $2.0_{a}$ | $2.5_{a}$ |
| | BK | $5.3_{ab}$ | $5.0_{a}$ | $5.8_{b}$ | $4.3_{a}$ | $3.5_{a}$ | $5.3_{ab}$ | $2.3_{a}$ | $1.8_{a}$ | $2.0_{a}$ |
| | MK | $5.5_{ab}$ | $5.0_{a}$ | $5.0_{ab}$ | $3.8_{a}$ | $3.2_{a}$ | $5.5_{ab}$ | $2.2_{a}$ | $2.0_{a}$ | $3.0_{a}$ |
| | CF | $6.3_{cd}$ | $5.0_{a}$ | $4.3_{a}$ | $3.7_{a}$ | $3.0_{a}$ | $4.5_{ab}$ | $2.3_{a}$ | $1.8_{a}$ | $2.2_{a}$ |
| Komboka | RF | $6.5_{d}$ | $6.2_{b}$ | $4.8_{ab}$ | $4.2_{a}$ | $4.0_{a}$ | $5.3_{ab}$ | $1.8_{a}$ | $2.3_{a}$ | $2.0_{a}$ |
| | BK | $5.7_{abc}$ | $6.3_{b}$ | $5.0_{ab}$ | $4.0_{a}$ | $3.8_{a}$ | $5.5_{ab}$ | $1.8_{a}$ | $2.2_{a}$ | $2.5_{a}$ |
| | MK | $5.8_{bcd}$ | $6.0_{b}$ | $5.7_{ab}$ | $3.7_{a}$ | $3.8_{a}$ | $4.7_{ab}$ | $2.5_{a}$ | $2.2_{a}$ | $2.2_{a}$ |
| | CF | $5.0_{a}$ | $6.0_{b}$ | $5.3_{ab}$ | $3.3_{a}$ | $3.3_{a}$ | $4.2_{a}$ | $2.2_{a}$ | $2.3_{a}$ | $2.5_{a}$ |
| **LSD** | | **0.7** | **0.6** | **1.3** | **1.1** | **1.3** | **1.7** | **1.0** | **1.0** | **1.2** |
| **CV (%)** | | **2.8** | **4.5** | **2.5** | **1.6** | **9.6** | **16.1** | **3.4** | **1.7** | **7.7** |

Data are means of three replicates. Means with letter(s) in common in the same column are not significantly different based on Fisher's Protected LSD Multiple Comparisons Test at $p<0.05$ significance level. RF – Rich Farm, BK – Han Daebak, MK – Han Yoobak, CF – Conventional Fertilizers, PI – Panicle initiation, DAT – Days after transplanting, Vigor Scale: 1 – Extra vigorous, 3 – Vigorous, 5 – Normal, 7 – Weak, 9 – Very weak.

**Tillers Fertility**

The results are recorded in Table 3.6. The highest total number of fertile tillers/$m^2$ were observed in standard check treatment (481.7, 96.1%) in Komboka variety, followed by same (477.3, 96.2%) in AT054 variety, Rich Farm (476.7, 95.0%) in Komboka variety, Rich Farm (475.0, 93.3%) in AT054 variety, Han Daebak (436.2, 92.0%) in AT054 variety, Han Daebak (432.9, 88.4%) in Komboka variety, and Han Yoobak (431.2, 92.8%) in AT054 variety, which were significantly higher compared to Han Yoobak (400.8, 86.1%) in Komboka variety. Conversely, the highest total number of non-fertile tillers/$m^2$ were observed in plots subjected to Han Yoobak (63.5, 13.9%) in Komboka variety, followed by Han Daebak (57.5, 11.6%) in Komboka variety, Han Daebak (40.0, 8.0%) in AT054 variety, Rich Farm (36.7, 6.7%) in AT054 variety and Han Yoobak (35.8, 7.2%) in AT054 variety, which were significantly higher compared to Rich Farm (26.7, 5.0%) in Komboka variety, Conventional fertilizers (21.0, 3.9%) in Komboka variety and Conventional fertilizers (19.2, 3.8%) in AT054 variety.

**Table 3.6 Effect of different organics products on tillers fertility of two rice varieties**

| | | Mature Grains (88 DAT) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **Regime** | **Hills/$m^2$** | **TT/H** | **FT/H** | **NFT/H** | **TT/$m^2$** | **FT/$m^2$** | **NFT/$m^2$** | **%FT/$m^2$** | **%NFT/$m^2$** |
| AT054 | RF | 25.0 | $20.5_{a}$ | $19.0_{b}$ | $1.5_{abc}$ | $511.7_{a}$ | $475.0_{b}$ | $36.7_{abc}$ | $93.3_{bc}$ | $6.7_{ab}$ |
| | BK | 25.0 | $19.1_{a}$ | $17.5_{ab}$ | $1.6_{abc}$ | $476.2_{a}$ | $436.2_{ab}$ | $40.0_{abc}$ | $92.0_{abc}$ | $8.0_{abc}$ |
| | MK | 25.0 | $18.7_{a}$ | $17.3_{ab}$ | $1.4_{abc}$ | $467.1_{a}$ | $431.2_{ab}$ | $35.8_{abc}$ | $92.8_{bc}$ | $7.2_{ab}$ |
| | CF | 25.0 | $19.9_{a}$ | $19.1_{b}$ | $0.8_{a}$ | $496.5_{a}$ | $477.3_{b}$ | $19.2_{a}$ | $96.2_{c}$ | $3.8_{a}$ |
| Komboka | RF | 25.0 | $20.1_{a}$ | $19.1_{b}$ | $1.1_{ab}$ | $503.3_{a}$ | $476.7_{b}$ | $26.7_{ab}$ | $95.0_{c}$ | $5.0_{a}$ |
| | BK | 25.0 | $19.6_{a}$ | $17.3_{ab}$ | $2.3_{bc}$ | $490.4_{a}$ | $432.9_{ab}$ | $57.5_{bc}$ | $88.4_{ab}$ | $11.6_{bc}$ |
| | MK | 25.0 | $18.6_{a}$ | $16.0_{a}$ | $2.5_{c}$ | $464.4_{a}$ | $400.8_{a}$ | $63.5_{c}$ | $86.1_{a}$ | $13.9_{c}$ |
| | CF | 25.0 | $20.1_{a}$ | $19.3_{b}$ | $0.8_{a}$ | $502.7_{a}$ | $481.7_{b}$ | $21.0_{a}$ | $96.1_{c}$ | $3.9_{a}$ |
| **LSD** | | | **2.2** | **2.1** | **1.3** | **56.1** | **52.3** | **33.4** | **6.4** | **6.4** |
| **CV (%)** | | | **1.0** | **1.3** | **5.7** | **1.0** | **1.3** | **5.7** | **0.5** | **6.1** |

Data are means of three replicates. Means with letter(s) in common in the same column are not significantly different based on Fisher's Protected LSD Multiple Comparisons Test at $p<0.05$ significance level. RF – Rich Farm, BK – Han Daebak, MK – Han Yoobak, CF – Conventional Fertilizers, H/$m^2$ – Hills/$m^2$, TT/H – Total tillers/hill, FT/H – Fertile tillers/hill, NFT/H – Non-fertile tillers/hill, DAT – Days after transplanting.

**Yield components**

The application of Rich Farm, Han Daebak and Han Yoobak as basal fertilizers as indicated in Table 3.7 had a significant effect on yield components; panicle length, panicle exsertion length, total spikelets/panicle, filled spikelets/panicle, non-filled spikelets/panicle and affected spikelets/panicle in both AT054 and Komboka varieties. The standard check, Conventional fertilizers produced significantly longer panicles in both Komboka (23.6 cm) and AT054 (23.5 cm) varieties, while Han Daebak (21.5 cm) treatment produced the shortest panicles in AT054 variety. Komboka variety had significantly higher panicle exsertion than AT054 variety. However, the standard check, Conventional fertilizers (2.8 cm) expressed higher panicle exsertion, followed by Han Yoobak (2.7 cm), Han Daebak (2.7 cm) and Rich Farm (2.2 cm) in Komboka variety. Han Daebak (0.3 cm) gave the highest panicle exsertion, followed by Han Yoobak (0.2 cm), Conventional fertilizers (0.1 cm) and Rich Farm (0.1 cm) in AT054 variety. The Conventional fertilizers (177.9) in Komboka variety recoded the highest total spikelets/panicle, followed by Rich Farm (166.2) in Komboka variety. Conventional fertilizers (147.4) and Rich Farm (140.0) in AT054 variety were significantly higher than that of Han Yoobak (132.4) and Han Daebak (131.4) in Komboka variety, Han Yoobak (127.9) and Han Daebak (118.5) in AT054 variety. Alike, the standard check, Conventional fertilizers (163.9, 92.0%) in Komboka variety recoded the highest number of filled spikelets/panicle, followed by Rich Farm (152.8, 91.4%) in Komboka variety, Conventional fertilizers (140.5, 95.2%) in AT054 variety and Rich Farm (131.2, 93.6%) in AT054 variety, which were significantly higher than that of Han Yoobak (118.8, 88.6%) and Han Daebak (115.7, 86.8%) in Komboka variety, Han Yoobak (115.1, 89.5%) and Han Daebak (107.5, 90.7%) in AT054 variety. The standard check, Conventional fertilizers (7.0, 4.8%), Rich Farm (8.3, 6.4%), Han Daebak (11.0, 9.3%) and Han Yoobak (12.9, 10.5%) in AT054 variety recorded the significantly lower non-filled spikelets/panicle, than that of Rich Farm (13.4, 8.6%), Han Yoobak (13.6, 11.4%), Conventional fertilizers (14.0, 8.0%) and Han Daebak (15.7, 13.2%) in Komboka variety. As per number of affected spikelets, Han Yoobak (5.9, 4.8%) in Komboka variety, followed by Conventional fertilizers (6.2, 3.6%) and Han Daebak (6.5, 8.7%) in Komboka variety, and Conventional fertilizers (6.7, 4.5%) in AT054 variety recorded significantly lower spikelets/panicle, than that of Rich Farm (7.6, 5.4%) in AT054 variety, Rich Farm (8.2, 5.3%) in Komboka variety, and Han Daebak (10.5, 5.4%) and Han Yoobak (11.2, 8.7% in AT054 variety. Among the different organic basal fertilizers applied, AT054 variety recorded significantly longer grain length compared to Komboka variety. All the applied basal organic fertilizers did not differ significantly in grain width observed between AT054 and Komboka variety.

**Table 3.7 Effect of different organics fertilizers on yield attributes of two rice varieties**

| | | Mature/Dry Grains (91 – 97 DAT) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **Regime** | **PL** | **PEL** | **TS/P** | **FS/P** | **NFS/P** | **AS/P** | **%FS/P** | **%NFS/P** | **%AS/P** | **GL** | **GW** |
| AT054 | RF | $21.6_{b}$ | $0.1_{a}$ | $140.0_{cd}$ | $131.2_{c}$ | $8.3_{a}$ | $7.6_{ab}$ | $93.6_{ef}$ | $6.4_{ab}$ | $5.4_{b}$ | $1.11_{b}$ | $0.23_{ab}$ |
| | BK | $20.5_{a}$ | $0.3_{a}$ | $118.5_{a}$ | $107.5_{a}$ | $11.0_{b}$ | $10.5_{c}$ | $90.7_{cd}$ | $9.3_{cd}$ | $5.4_{b}$ | $1.11_{b}$ | $0.23_{ab}$ |
| | MK | $21.5_{b}$ | $0.2_{a}$ | $127.9_{ab}$ | $115.1_{ab}$ | $12.9_{c}$ | $11.2_{c}$ | $89.5_{bc}$ | $10.5_{de}$ | $8.7_{c}$ | $1.15_{c}$ | $0.23_{ab}$ |
| | CF | $23.5_{d}$ | $0.1_{a}$ | $147.4_{d}$ | $140.5_{c}$ | $7.0_{a}$ | $6.7_{ab}$ | $95.2_{f}$ | $4.8_{a}$ | $4.5_{ab}$ | $1.13_{bc}$ | $0.24_{b}$ |
| Komboka | RF | $22.5_{c}$ | $2.2_{b}$ | $166.2_{e}$ | $152.8_{d}$ | $13.4_{c}$ | $8.2_{b}$ | $91.4_{d}$ | $8.6_{c}$ | $5.3_{b}$ | $0.83_{a}$ | $0.22_{a}$ |
| | BK | $23.0_{cd}$ | $2.7_{c}$ | $131.4_{bc}$ | $115.7_{ab}$ | $15.7_{d}$ | $6.5_{ab}$ | $86.8_{a}$ | $13.2_{f}$ | $8.7_{c}$ | $0.82_{a}$ | $0.23_{ab}$ |
| | MK | $22.6_{c}$ | $2.7_{c}$ | $132.4_{bc}$ | $118.8_{b}$ | $13.6_{c}$ | $5.9_{a}$ | $88.6_{b}$ | $11.4_{e}$ | $4.8_{ab}$ | $0.83_{a}$ | $0.23_{ab}$ |
| | CF | $23.6_{d}$ | $2.8_{c}$ | $177.9_{f}$ | $163.9_{e}$ | $14.0_{cd}$ | $6.2_{a}$ | $92.0_{de}$ | $8.0_{bc}$ | $3.6_{a}$ | $0.83_{a}$ | $0.22_{a}$ |
| **LSD** | | **0.8** | **0.4** | **10.6** | **10.8** | **1.9** | **1.8** | **1.7** | **1.7** | **1.4** | **0.03** | **0.01** |
| **CV (%)** | | **1.0** | **5.9** | **7.2** | **7.5** | **11.5** | **15.6** | **1.2** | **12.5** | **15.5** | **0.10** | **1.00** |

Data are means of three replicates. Means with letter(s) in common in the same column are not significantly different based on Fisher's Protected LSD Multiple Comparisons Test at $p<0.05$ significance level. RF – Rich Farm, BK – Han Daebak, MK – Han Yoobak, CF – Conventional Fertilizers, PL – Panicle length (cm), PEL – Panicle exsertion length (cm), TS/P – Total spikelets/panicle, FS/P – Filled spikelets/panicle, NFS/P – Non-filled spikelets/panicle, AS/P – Affected spikelets/panicle, DAT – Days after transplanting.

**Dry grains yield**

An interaction effect was noticed (Table 3.8) between variety and the application of different basal fertilizers on dry grains yield of rice. The significantly higher dry grains yield were observed in Conventional fertilizers (5.4 ton/ha) in Komboka variety, followed by Rich Farm (5.3 ton/ha) in Komboka variety, Conventional fertilizers (5.1 ton/ha) in AT054 variety and Rich Farm (4.9 ton/ha) in AT054 variety, than that of Han Yoobak (4.7 ton/ha) in AT054 variety, Han Daebak (4.3 ton/ha) in AT054 variety and Han Yoobak (4.1 ton/ha) in Komboka variety. The lowest dry grains yield (3.9 ton/ha) was obtained from Han Daebak in Komboka variety. The 1000-seed grain weight was unaffected by the basal application of Rich Farm, Han Daebak and Han Yoobak organics and the standard check, Conventional fertilizers, but was significantly affected by the rice variety.

**Table 3.8 Effect of different organics fertilizers on dry grain yield of two rice varieties**

| | | Dry Grains (97 DAT) | | | | |
|---|---|---|---|---|---|---|
| **Variety** | **Regime** | **Grams/m$^2$** | **Kg/Acre** | **Ton/Ha** | **1,000-Seed Weight (g)** | **MC (%)** |
| AT054 | RF | $488.8_{bcd}$ | $1,955.0_{bcd}$ | $4.9_{bcd}$ | $26.7_{a}$ | 14.0 |
| | BK | $430.5_{abc}$ | $1,722.0_{abc}$ | $4.3_{abc}$ | $26.7_{a}$ | 14.0 |
| | MK | $468.6_{abcd}$ | $1,874.0_{abcd}$ | $4.7_{abcd}$ | $28.3_{a}$ | 14.0 |
| | CF | $511.1_{cd}$ | $2,045.0_{cd}$ | $5.1_{cd}$ | $28.3_{a}$ | 14.0 |
| Komboka | RF | $526.7_{cd}$ | $2,107.0_{cd}$ | $5.3_{cd}$ | $28.3_{a}$ | 14.0 |
| | BK | $388.2_{a}$ | $1,553.0_{a}$ | $3.9_{a}$ | $26.7_{a}$ | 14.0 |
| | MK | $405.6_{ab}$ | $1,622.0_{ab}$ | $4.1_{ab}$ | $30.0_{a}$ | 14.0 |
| | CF | $543.6_{d}$ | $2,174.0_{d}$ | $5.4_{d}$ | $28.3_{a}$ | 14.0 |
| **LSD** | | **99.3** | **397.0** | **1.0** | **5.0** | |
| **CV (%)** | | **7.1** | **7.1** | **7.1** | **1.3** | |

Data are means of three replicates. Means with letter(s) in common in the same column are not significantly different based on Fisher's Protected LSD Multiple Comparisons Test at $p<0.05$ significance level. RF – Rich Farm, BK – Han Daebak, MK – Han Yoobak, CF – Conventional Fertilizers, DAT – Days after transplanting.

## IV. Discussion

Previous studies have revealed that the application of organic fertilizers aid to improve the soil physicochemical properties, soil nutrients, thus increasing the yield and quality of crops[16,17]. Data in this study pertaining to plant attributes (plant height, number of tillers), yield components (fertile tillers, panicle length, panicle exsertion length, total spikelets, filled spikelets, non-filled spikelets, affected spikelets) and dry grain yield were significantly influenced by the basal application of the test organic fertilizers; Rich Farm (fish meal, bone meal, blood meal), Han Daebak (castor meal, rice bran, chicken meal, bone meal), Han Yoobak (castor oil meal, rapeseed oil meal, rice bran) and the standard check, Conventional fertilizers (DAP, MOP). It can be assumed that these fertilizers played a major role in the effects observed, as they provided varying strength of nitrogen and phosphorus during early stages of crop growth depending on C/N ration[18]. Organic fertilizers are rich in organic carbon which directly functions to increase the total nitrogen and soil organic carbon[19], improve soil pH to neutral level that enhance soil microbial activities[20] and improve the size of soil aggregates[21]. The possible reasons for the observed variation in data in this study could be attributed to varying amount of nitrogen, phosphorus and potassium that was supplied to the soil through the basal application of Rich Farm (8-3-3), Han Daebak (3.8-2-1.2), Han Yoobak (4-2-1) and DAP (18-46-0) + MOP (0-0-49.8).

Agronomic characters are viewed as factual basis of plant development and the external indicator of yield formation. Among the test basal organic fertilizers; application of Rich Farm and Han Daebak resulted in the tallest plants in both AT054 and Komboka variety. The highest number of tillers/m$^2$ was attained by basal application of Rich Farm in both varieties, while lowest number of tillers/m was attained by basal application of Han Yoobak in AT054 variety. These results were similar to the recommended standard check. These finding are in agreement with previous studies which have shown that application of appropriate amount of bioorganic fertilizers have positive effect on crop growth and development, such as; increasing plant height and length of lateral branches[22,23,24,25]. For instance, application of castor bean meal fertilizer increased plant height, stalk diameter, fresh stem weight, fresh leaf weight and ear weight in maize[26]. Comparably,[27] reported that application of castor blends (meal, husks) as fertilizer prompted plant growth up to optimal rate (4.5%), but high doses reduced plant. In other studies, application of rapeseed meal was shown to increase the plant height of rice crop but efficient nitrogen supply was achieved by mixing rapeseed meal with chemical fertilizers[28].

Tillering is a crucial part of rice growth enhancement while tillers' fertility is an important feature for grain yield[29]. Different organic fertilizers have influence on production of tillers and tillers fertility (tillers with panicles) in rice crop. Fertility of the rice tillers is largely determined by the number of panicles formed rather than the total number of tillers per unit area[29]. In the present study, maximum number of fertile tillers was attained by basal application of Conventional fertilizers in both varieties, followed closely by Rich Farm organic fertilizer, but the other organic fertilizers; Han Daebak and Han Yoobak were enough to produce statistically equal number of fertile tillers. Different mixtures of fertilizers have been shown to increase the number of tillers in rice crop due to related increase in nitrogen availability which enhances division of the cells[30]. Organic fertilizers provide plants with better balanced micronutrients that effect the number of tillers[31]. In this study, basal application of Conventional fertilizers produced high number of fertile tillers, which could be owing to the high percentage of nitrogen content. These findings are in line with previous studies which have indicated that the number of panicles – a product of productive/fertile tillers increased with increased amount of nitrogen[32,33].

The number of total, filled and non-filled spikelets/panicle had significant different between the two rice varieties and the treatments. Among the tested organic fertilizers, results indicated that basal application of Rich Farm was significantly higher on number of total and filled spikelets/panicle with lower number of non-filled spikelets/panicle in both varieties, and were on par with that of Conventional fertilizers. Also, basal application of Farm Rich recorded significantly longer panicles in both varieties compared to other test organic fertilizers. Application of rapeseed mean was shown to increase dry weight, number of spikelets/panicle, ripening rate and 1,000-seed weight of rice over the control but was on par with the application of chemical fertilizers[28]. Application of castor de-oiled cake mixed with NPK+Zn significantly improved grains/panicle, grain yield and straw of rice crop over the control and was on par the application recommended NPK doses[34].

Previous studies have indicated that the use of organic fertilizer not only encourage growth and expansion of crops[35,36] but also boost crop yield quality by improving photosynthetic conditions and increasing biomass[37,38]. In the current study, the dry grain yield from all test organic fertilizers was numerically lower, but statistically similar to the recommended standard check. These findings concur with[39] who reported lower rice yield from organic farming with winter flooding than conventional farming. Similarly,[40] reported that fall application of organic fertilizer (rice bran) did not result in increase of rice grain yield. Application of rapeseed as green manure increased rice grain yield by promoting number of tillers[41]. Tied to this, other studies indicated that the yield and quality of rice was enhanced when rice crop was rotated with rapeseed compared to other crops as a result of an increase in effective number of panicles and grains/panicle and accumulated nitrogen content[42,43]. Rice yield was shown to increase with heavy application of rice bran at early stages of crop growth combined with top dressing with nitrogen at panicle formation stages[44]. Elsewhere, application of rice bran showed increase in cassava production[45]. In other crops, application of 25% phosphorous through fish bone meal (FBM) and remaining through mineral fertilizers significantly increased the growth, yield components, grain yield and stover yield of soybean[46].

As a whole, the lesser results obtained for the test basal organic fertilizers; Rich Farm, Han Daebak and Han Yoobak can be equated to low concentrations of nitrogen, phosphorus and potassium contained in these fertilizers, that could have affected the absorption of aforementioned nutrients by the crop compared to the high concentrations in recommended standard check (DAP + MOP). The substantial disparity in the plant height, panicle length, sum of tillers, spikelets and dry grain yield between the two varieties can also be attributed to genetic differences in their ability to utilize fertilizers. Also, variation of the results of this study with the quoted authors may be due to influence of climate, soil quality, type of crop, type and formulation of organic fertilizers, time of application, mode of application, among other factors. The promising rice production with basal organic fertilizers tested when well utilized will not only enhance rice yield, but also help to promote eco-friendly agriculture that supports biodiversity in rice production systems.

## V. Conclusion And Recommendations

The basal application of organic fertilizers; Rich Farm, Han Daebak and Han Yoobak did not result in significantly higher grains yield than the standard check (DAP+MOP). However, similar yields were obtained. In relation to the recommended Convention fertilizers, Rich Farm organic was superior in tillers/m$^2$, panicle length, total spikelets/panicle, filled spikelets/panicle and dry grain yield of both rice varieties over the Han Daebak and Han Yoobak organics, and therefore can be recommended as basal organic fertilizers in both AT054 and Komboka varieties. On the other hand, Han Daebak can be used in AT054 variety for rice production. Although, Rich Farm organic fertilizer gave best results among the tested organics, its main composition (animal proteins; fish meal, bone meal, blood meal) has little-known information on its use as fertilizer in crops. This is among the initial studies to investigate the effect of animal proteins in rice farming in Kenya. Hence these findings could lead to new insights for improving rice yield with animal proteins. Considering that this is a one season result, further studies are required to investigate the long-term effects of these organic fertilizers on the soil properties in the study area, as well as evaluating the optimal rates for higher rice production.

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**Conflict of Interest**

The authors have no conflicts of interest to declare.

## Annexes

**Annex I: Description of basal fertilizers used**

| Code | Description | Source | Composition | Experimental | Commercial use |
|---|---|---|---|---|---|
| RF | Rich Farm (8-3-3-CaO)<br>Rate: 200 Kg/Ha | Animal protein;<br>- fish meal<br>- bone meal<br>- blood meal | 8% N, 3% $P_2O_5$, 3% $K_2O$, Others: sulfur, calcium, iron, liver, olive oil | Test | - Slow releasing animal protein fertilizer used as basal fertilizer in vegetables (leafy, root, fruit), fruits, flowers, irrigation (rice)<br>- It has the effect of softening the soil |
| BK | Han Daebak (3.8-2-1.2)<br>Rate: 200 Kg/Ha | Castor meal<br>Rice bran<br>Processed;<br>- chicken meal<br>- bone meal | 3.8% N, 2% $P_2O_5$, 1.2% $K_2O$<br>Others: 45% castor meal, 35% rice bran, 10% chicken meal, 10% bone meal, >60% organic matter | Test | - Mixed fertilizer pellets used in fruits, horticulture, irrigation (rice)<br>- It improves physical properties of the soil and the activity of the soil microorganisms |
| MK | Han Yoobak (4-2-1)<br>Rate: 200 Kg/Ha | Castor oil meal<br>Rapeseed oil meal<br>Rice bran | 4% N, 2% $P_2O_5$, 1% $K_2O$<br>Others: 40% rapeseed oil cake, 40% castor oil cake, 20% rice bran, >70% organic matter | Test | - Mixed fertilizer pellets used in fruits, horticulture, irrigation (rice)<br>- It improves acidic soil by promoting the growth of microorganisms in the soil |

| | | | | | |
|---|---|---|---|---|---|
| CF | Conventional fertilizers<br>200 Kg/Ha DAP<br>120 Kg/Ha MOP | DAP<br>MOP | DAP; 18% N, 46% $P_2O_5$<br>MOP; 60% $K_2O$, 49.8% K | Local check | - Stimulates growth of strong stems with resistant to diseases<br>- Enhances strong root development |

## Appendix II: Rice agronomic traits rating scale

| Tillering Ability (Ti) | |
|---|---|
| **Scale** | **Description** |
| 1 | Very high (more than 25 tillers/plant) |
| 3 | Good (20-25 tillers/plant) |
| 5 | Medium (10-19 tillers/plant) |
| 7 | Low (5-9 tillers/plant) |
| 9 | Very low (less than 5 tillers/plant) |
| **Seedling Vegetative Vigor (Vg)** | |
| **Scale** | **Description** |
| 1 | Extra vigorous (very fast growing; plants at 5-6 leaf stage have 2 or more tillers in majority of population) |
| 3 | Vigorous (fast growing; plants at 4-5 stage have 1-2 tillers in majority of population) |
| 5 | Normal (plant at 4-leaf stage) |
| 7 | Weak (plants somewhat stunted; 3-4 leaves; thin population; no tiller formation |
| 9 | Very weak (stunted growth; yellowing of leaves |

(Source: IRRI, 2002)

## Annex III: Description of data collection on rice parameters

| No. | Parameter | Description |
|---|---|---|
| 1 | Plant stand | Hills/m$^2$ sprouting from transplanted rice crop were counted manually |
| 2 | Plant height | Actual measurements (cm) from soil surface to the tip of tallest 20 plants from 20 hills/plot within 1m$^2$ were recorded in whole number. The height was measure by use of 1 m ruler |
| 3 | Tillers | Number of tiller/hills sprouting from transplanted rice crop were individually counted from 3 hills per sample for 4 samples/plot. They were averaged and then multiplied by the number of hills/m$^2$ to give the final number of tillers/m$^2$ |
| 4 | Tillering ability | Ability to till was rated on 4 hill/m$^2$ per plot based on the scale provided |
| 5 | Plant vigour | Vigor of plants was rated on 4 hills/m$^2$ per plot based on the scale provided |
| 6 | Fertile tillers | Number of fertile tillers/hill were individually counted at reproductive stage (as No. 2 above), averaged and then multiplied by the number of hills/m$^2$ to give the final number of fertile tillers/m$^2$ |
| 7 | Panicle length and panicle exsertion length | From 20 panicles/plot, actual measurements (cm) from neck node to the tip of main panicle and from the leaf cushion of flag to the neck node were recorded for panicle length and panicle exsertion length, respectively. The measurements were taken by 30 cm ruler |
| 8 | Grain filling/spikelet fertility | 20 panicles/plot within selected to count the number of totals, filled, non-filled and affected spikelets/panicle, and expressed into percentage. Number of fertile spikelets were identified by pressing the spikelets with the fingers and noting those that have grains |
| 9 | Grain yield | Yield (Kg) was determined after threshing and sun-drying mature grains/m$^2$ area of each plot. 1-000 seeds were counted and weighed as well. Ramtons 5KG-RM/299 electronic digital gram-scale was used to weigh the grains. Moisture content (%) was determine by Dramisnski® Grain Moisture Meter and grain yield weight standardize to 14% MC, then expressed in Ton/Ha |
| 10 | Grain length and grain width | Actual measurements (cm) of 20 individual rice grains/plot were recorded. As for individual grain width, 5-grains width was taken and divided by 5 to get width length for individual grain from 2o samples/plot. The measurements were taken by 30 cm ruler |
| 11 | Yield standardization | Grain yield was standardized to standard moisture content based on the formula by[47] shown below; $SYW = HYW \times \frac{(100\% - HMC)}{(100\% - SMC)}$ Where; SYW = Standard Yield Weight, HY = Harvest Yield Weight, HMC = Harvest Moisture Content (%), SMC = Standard Moisture Content (%) |

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