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Improving Grain Productivity and Quality Criteria of Broadcasted Giza 179 Rice Variety Via different Potassium Treatments

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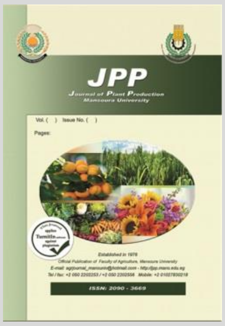

ABSTRACT

Field experiments were conducted in the 2018 and 2019 seasons at the Experimental Farm of Sakha Agriculture Research Station, Kafr-ELSheikh, and laboratory experiments conducted at Seed Technology Department, Field Crops Research Institute A.R.C. Giza, Egypt. The study aimed to evaluate the influence of different potassium application methods as follow, control treatment (no potassium application), 50 Kg K_2O/ha as one basal batch and two splits, ½ as basal and ½ at 25 days after sowing and foliar potassium concentrations (0, 0.5, 1 and 1.5 % K_2O) on Giza 179 rice variety. Twelve combinations were performed in a randomized complete block design with four replications. Yield attributes and grain yield, as well as grain quality charcteristics which involved grain dimension, milling recovery charcteristics, amylose content (AC), gel consistency (GC), gelatinization temperature (GT), and kernel elongation, were estimated. The findings revealed that splitting potassium fertilizer plus applying foliar application at the rate of 1.0 % lead to preferable yield attributes outcome, outstripped grain yield by 12.63 and 11.93 %, and ameliorated both of head rice percentage by 9.87 and 8.29 %, AC content by 4.19 and 4.02 % and decreased GC by 0.59 and 0.88 %, respectively in both seasons compared with one batch basal application. Using splitting potassium application plus foliar spray at 1.0 % K_2O can apply to Giza 179 rice variety to optimize both of grain quantity and quality outcomes. Influence of different potassium treatments exhibited a significant effect on Seed Technology characteristics results.

Keywords: Rice, potassium fertilizer, yield, yield attributes, grain quality, and seed technology.

INTRODUCTION

Rice (*Oryza sativa* L.) is a crucial cereal crop that provides more than 25% of the calorific demands of 50% of the world's inhabitants (Kusano *et al.*, 2015). The agriculture sector has a very complex challenge to improve both rice quantity and quality under the current land and the same conditions. Grain quality has closely related to the acceptability of rice for export and domestic markets and also determines price revenue. Accordingly, a lot of efforts have to do with optimization grain quality on par with grain yield production. The qualities of rice grain traits can improve by several strategies such as traditional breeding methods, mutation breeding, and agronomic methods by supplemental various nutrients.

The ingredients of milled rice (table consumed form) are broken rice and unbroken rice (head rice). Broken rice is identified as a shard of grains which less than the whole milled rice by about ¾. Regrettably, rice markets and consumers only consume head rice and also refuse a lot amount of rice grain if it contains a high percentage of unbroken rice (Bao, 2012). It is noteworthy that, the criteria for grain quality can be clustered into three major characteristics as follows, physical characteristics (visual characteristics and milling recovery), chemical components (moisture, starch, protein, lipid, crude fiber, ash, and mineral), cooking and eating properties (amylose content, gel consistency, gelatinization temperature, and grain elongation). Egyptian rice breeders have specific purposes that aim to incorporated short duration value with high grain yield production. Giza 179 is a new Egyptian rice variety with high grain outcomes (>10 ton ha^{-1}) with a short duration value (about 125 days) but ashamedly, it has a high percentage of broken rice (Negm and Abu-hashim, 2019). Hence, Egyptian growers refuse the cultivation of Giza 179 rice variety despite its advantages.

Benign rice quantity and quality outcome requires a balanced essential nutrient (nitrogen, phosphor, and potassium) supply. Potassium (K) is one of the nutrient pillars that underpin crop production and boost grain quality. By its impacts on various enzymatic and physiological processes such as water relations, enzyme activation, photosynthesis process, opening, and closing stomata during gas exchange and protein and starch synthesis, K has a pertinent relationship on rice production and grain quality (Pettigrew, 2008 and Rawat *et al.*, 2016). It is noteworthy that, potassium has a major role in grain quality, therefore it is often termed with a quality element (Usherwood, 1985). The large and continuous requirement of potassium fertilizers up to the heading stage is well documented in previous studies as a good route in optimizing rice crop productivity (Fageria *et al.*, 2010, Jian-chang, 2004 and Atapattu *et al*., 2018). Atapattu *et al.* (2018) reported that the addition of high K fertilizer rates (37.5 kg/ha K_2O) in the heading stage gave the best grain yield, head rice, and milling percentage. On the other hand, split potash fertilizer into equal doses (½ at basal and ½ after 25 from transplanting) caused maximal yield component and grain outcomes (Awan *et al.*, 2007).

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The fortification of K nutrient with foliar application in various growth stages has been described in earlier studies by Jayaraj and Chandrasekharan (1997). They found a significant increase in rice grain yield when the plant's exposed to potash foliar application (K_2O solution) in the booting and flowering stages. Metwally and Gharib (2011) and Zayed *et al.* (2011) claimed that dividing soil potassium fertilizers plus foliar K application as K_2O solution at mid tillering and panicle initiation gave the best findings in grain yield outcomes and enrichment grain with nutrients (N, P, K, and Zn) as well as rice grain quality.

From seed germination to seed production, plants require various macronutrients and micronutrients. Potassium is one of the most important macronutrients, along with nitrogen (N) and phosphorous (P). Potassium is required for various biochemical and physiological processes that are responsible for plant growth and development. Potassium takes part in protein synthesis, carbohydrate metabolism. Potassium salts have been thoroughly studied as good catalysts for improving seed germination and the emergence rate. Potassium assists in seed germination by initiating the rapid imbibition of water, and it also facilitates other physiological processes. Potassium salts have been thoroughly studied as good catalysts for improving seed germination and the emergence rate. Hasanuzzaman *et al.* (2018).

On that basis, this study was conducted to determine the best-suited potassium treatment as a basal and foliar application to optimizing both rice grain quantity and quality outcomes for Egyptian rice variety Giza 179.

MATERIALS AND METHODS

A-Field Experiments

Two field experiments were conducted at the Experimental Farm of Sakha Agriculture Research Station, Sakha, Kafr El-Sheikh, Egypt during the 2018 and 2019 seasons. The previous crop was wheat during both seasons of the study.Giza179 rice cultivar (developed from the local cross GZ 6296-12-1-2-1-1/GZ 1368-S-5-4) was used in this study**.**

B-Physical and chemical soil analysis

Representative soil samples were randomly taken from the site at the depth of 0-30 cm. The chemical and physical properties of soil were analyzed according to Black *et al.* (1965). The analytical result properties of the soil in the experimental site are presented in Table (1).

Table 1. Physical and chemical analysis of the experimental sites in 2018 and 2019 seasons.

Character	2018	2019
physical analysis :		
Texture	Clayey	Clayey
Sand (%)	16.5	15.3
Silt (%)	28.0	30.0
Clay (%)	55.5	54.7
Chemical analysis:		
pH (1:2.5 soil extract)	8.25	8.11
E.C. (dSm-1)	1.86	1.80
Organic matter %	1.65	1.51
Available N (ppm)	18.2	17.3
Available P (ppm)	16.7	14.2
Available K (ppm)	316	313
Available Zn (ppm)	1.00	0.95
Available Mn (ppm)	3.94	3.10
Available Fe (ppm)	2.95	2.63

C-Experimental design and treatments

The experiment was laid out in a completely randomized block design with four replication. The plot size was 15 m^2 (5 m x 3 m). Potassium nitrate (KNO_3) is the source of foliar potassium application in this study. The treatments included two main potassium application methods (basal and foliar applications) and their combinations. Basal application (control, 50 Kg K_2O/ha and two equal splits, ½ as basal and ½ at 25 days after sowing) and foliar applications concentrations (0, 0.5, 1 and 1.5 % K_2O) in panicle initiation (PI) and complete heading (CH) stages used in this investigation as follows:

1. K_0: without basal or foliar application (control)**.**
2. K_1: foliar application at PI, and CH at the rate of 0.5 % K_2O.
3. K_2: foliar application at PI, and CH at the rate of 1 % K2O.
4. K_3: foliar application at PI, and CH at the rate of 1.5 % K2O.
5. K_4: 50 Kg K_2O/ha as one batch.
6. K_5: 50 Kg K_2O/ha + foliar application at PI, and CH at the rate of 0.5 % K_2O.
7. $K_{6:}$ 50 Kg K_2O/ha + foliar application at PI, and CH at the rate of 1 % K_2O.
8. K_7: 50 Kg K_2O/ha + foliar application at PI, and CH at the rate of1.5 % K_2O.
9. K_8: ½ as basal and ½ top-dressed at 25 days after sowing.
10. K_9: ½ as basal and ½ top-dressed at 25 days after sowing + foliar application at PI, and CH at the rate of 0.5 % K_2O.
11. K_{10}: ½ as basal and ½ top-dressed at 25 days after sowing + foliar application at PI, and CH at the rate of 1 % K_2O.
12. K_{11}: ½ as basal and ½ at 25 days after sowing. + foliar application at PI, and CH at the rate of 1.5 % K_2O.

D-Crop management

The experimental sites were well tillage. Pre-germinated seeds were broadcasted on 2 and 5 of May in the 2018 and 2019 seasons, respectively. Seeds at the rate of 140 kg /ha were soaked in excess of water for 24 hours and further incubated for another 48 hours to enhance germination. Weeds were chemically controlled using Saturn 50% at the rate of 5 liters /ha at seven days after sowing. Nitrogen in the form of urea (46% N) at the rate of 165 kg/ha was applied as recommended in three doses; 1/3 applied as a basal application in dry soil before flooding, 1/3 applied after 30 days from cultivation, and 1/3 at the panicle initiation stage. The recommended phosphorous fertilizers in the form of calcium superphosphate (15 ٪ P_2O_5) at a rate of 37 kg/ha before land preparation. Potassium sulfates (48% K_2O) at the rate of 50 kg K_2O kg/ ha was applied as above mentioned. Zinc fertilizer applied at the rate of 24 $ZnSO_4$ kg/ ha was mixed with sand and manually broadcasted after well leveling and before broadcast.

E-Studied topics and traits

E-1-Yield and yield attributes

Perior to harvest, plant height was measured and the panicles / m^2 from each plot were counted. Ten panicles were randomly collected from each plot to determine the number of filled grains/ panicle, unfilled grains/ panicle, panicle weight (g), and 1000-grain weight (g). Biological yield (the aggregate of total grain and straw yield) was measured from an area of 12m^2 which was harvested from each plot at random avoiding the border effects. Grain yield was adjusted to 14% moisture content determined according to Yoshida (1981). Harvest index (HI) is estimated as a ratio between both grain and biological yield.

E-2-Grains quality

One hundred and fifty grams of grains were taken from each treatment, mixed, and sent to the grain quality laboratory at the RRTC to determine grain quality characteristics according to International Rice Research Institute (IRRI 1996).

The studied grain quality characteristics included grain physical characteristics which encompass visual characteristics of grain dimension (grain length (L) (mm), grain width (W) (mm), grain thickness (mm), and grain shape which estimated with L/W ratio and milling recovery characteristics (Hulling percentage, milling percentage, and head rice percentage). Cooking and eating quality characteristics encompassed amylose content (%), gel consistency (GC), gelatinization temperature (GT), and kernel elongation after cooking (%).

E-3- Seed Technology characteristics

Seed technology characteristics were carried out under the laboratory conditions of Seed Technology Department, Field Crops Research Institute A.R.C. during the 2018 and 2019 seasons to assess the quality of the studied rice grains. Samples of seeds were separately germinated in 9 cm Petri dishes lined with Whatman filter paper (90 mm size) wetted with 7 ml distilled water, Petri dishes were kept in growth room of temperature 25±2° C, the relative humidity of 50-70% and photoperiod of 12h light/12h dark (Khan *et al.*, 2019). There were four replicates per treatment. Seed germination was recorded daily for ten days and the seed was considered germinated if the emerged radicle measures about 2mm. (Ali *et al.,* 2020). Normal seedlings were counted and expressed as the germination percentage. At the final count, ten normal seedlings from each replicate were taken to measure the root and plumule length (cm).

Germination percentage is calculated as:

GP = (No. of seeds normally germinated total) / (No. of seeds germinated) X 100

Seedling vigor index was calculated as:

SVI = Seedling length X Germination percentage.
(ISTA, 2004).

Chemical properties of grain which included protein and carbohydrate were determined according to the procedures outlined by (AOAC, 2000).

F-Statistical analysis

The obtained data were subjected to analysis of variance according to Gomez and Gomez (1984). Treatment means were compared by least significant difference (LSD 0.05). All statistical analyses were performed using the analysis of variance technique using “COSTATC” computer software package.

RESULTS AND DISCUSSION

E-1- Yield attributes

As shown in Tables 2 and 3, there was a considerable difference among all studied characteristics and progressive response to K fertilizers (soil and foliar) additions in both seasons. Splitting potash twice with foliar addition of K_2O at 1.5% (K_{11}) outstripped on other treatments in giving the tallest plant, the highest number of panicles / m^2, maximally filled grains number /panicle, least unfilled grains number/panicle, supremely of both panicle and 1000- grains weights in 2018 and 2019 rice seasons. The obtained data didn't appear any significant difference between the treatment of K_{11} and K_{10} in all the above-mentioned characteristics. The number of panicles /m^2 recorded the highest value when the recommended was added in two equal doses and there was no significant difference observed between K_8, K_9, $K_{10,}$ and K_{11} in both cultivated seasons. However, the treatments of foliar application contributed to obtaining the most number of filled grains /panicles when the potassium application was applied in one or two batches. Whereby, the treatment of K_5 gave identical statistically with K_6, K_7, K_8, K_9, $K_{10,}$ and K_{11} treatments in the 2018 and 2019 seasons. Inversely, the empty grains noticeably decreased under $K_{5,}$ K_6, K_7, K_8, K_9, $K_{10,}$ and K_{11} in the 2018 season and K_6, K_7, K_8, K_9, $K_{10,}$ and K_{11} in the 2019 season without significant difference between them. As for panicle weight, it rendered a statistical similarity among K_{11}, K_{10}, K_9, $K_{8,}$ and K_7 in both seasons. The heaviest weight of 1000- grain was recorded under K_{11} treatment with statistically identical with K_5, K_6, K_7, K_8, $K_{9,}$ and K_{10} in the 2018 season and with K_6, K_7, K_8, $K_{9,}$ and K_{10} in the 2019 seasons. Treatment of K_0 (control) recorded the lowest value among all tested characteristics.

Table 2. Influence of potassium treatments on plant height, number of panicles /m^{2,} and the number of filled grains /panicle of Giza179 rice variety during 2018 and 2019 seasons.

Term	B_1 Kg/ha	B_2 Kg/ha	F.C (%)	Plant height(cm)		Number of panicles /m^2		Number of filled grains /panicle	
				2018	2019	2018	2019	2018	2019
K_0	-	-	-	90.2	88.6	466.7	459.3	98.9	94.0
K_1	-	-	0.5	91.8	90.4	470.3	451.0	100.1	98.2
K_2	-	-	1.0	94.3	92.6	473.0	465.0	104.6	100.2
K_3	-	-	1.5	94.8	93.6	476.0	468.0	107.0	102.1
K_4	50	-	-	96.1	94.4	490.3	474.0	109.4	110.4
K_5	50	-	0.5	96.6	94.8	494.0	491.7	112.6	112.0
K_6	50	-	1.0	97.1	95.3	503.5	494.2	113.8	112.2
K_7	50	-	1.5	97.4	96.1	506.3	500.0	117.2	114.3
K_8	25	25	-	98.0	95.8	516.0	507.2	115.1	113.9
K_9	25	25	0.5	98.4	97.2	520.0	510.9	118.3	117.2
K_{10}	25	25	1.0	100.2	98.1	521.0	515.1	121.2	120.0
K_{11}	25	25	1.5	101.8	98.8	522.0	518.2	122.6	120.3
LSD 5%				1.4	1.7	8.4	8.9	2.3	2.6

B_1: the first basal batch, B_2: the second basal batch, F.C: foliar concentrations.

Table 3. Influence of different potassium treatments on the number of unfilled grains /panicle, panicle weight, and 1000 grain weight of Giza179 rice variety during the 2018 and 2019 seasons.

Term	B_1 Kg/ha	B_2 Kg/ha	F.C (%)	Number of unfilled grains /panicle		Panicle weight(g)		1000- grain weight(g)	
				2018	2019	2018	2019	2018	2019
K_0	-	-	-	18.8	19.6	2.83	2.86	25.10	25.10
K_1	-	-	0.5	12.6	16.2	2.91	2.82	25.33	25.15
K_2	-	-	1.0	10.5	14.0	3.08	2.93	25.41	25.53
K_3	-	-	1.5	7.6	8.6	3.17	3.11	26.29	25.77
K_4	50	-	-	6.1	6.8	3.62	3.40	26.31	26.18
K_5	50	-	0.5	5.6	6.1	3.70	3.46	26.46	26.29
K_6	50	-	1.0	5.2	5.6	3.78	3.58	26.63	26.67
K_7	50	-	1.5	5.0	5.5	3.91	3.71	26.84	26.73
K_8	25	25	-	4.4	5.1	3.87	3.68	26.52	26.60
K_9	25	25	0.5	4.8	5.0	3.95	3.70	27.01	26.92
K_{10}	25	25	1.0	4.1	4.8	4.11	3.88	27.12	27.00
K_{11}	25	25	1.5	3.7	4.3	4.18	3.96	27.25	27.11
LSD 5%				1.8	1.8	0.7	0.5	0.4	0.6

B_1: the first basal batch, B_2: the second basal batch, F.C: foliar concentrations.

Nevertheless, there was a marginal enhancement happened in yield attributes under individually foliar application treatments (K_1, K_2, and K_3) as compared with K_0. These implications may be due to the over needs of modern varieties with high yielding value to having a lot amount of K fertilizers around the plant life cycle to achieve the desired yield (Sharma *et al.*, 2013). Probably, splitting potassium application causes better encouragement for photosynthesis rate which is reflected in enhancement carbohydrate metabolism at the pre-heading period resulted in obtaining higher and faster translocate to sink parts or panicles (Gobi *et al.*, 2008). Earlier studies by Beringer (1978) and Pettigrew (2008) found that K- fertilizer acts as a catalyzer action for translocation and accumulation of photo-assimilates to panicle and spikelets. Furthermore, it has a substantial role in expanding cells and developing proper roots which rendered optimizing nutrients uptake and heavier grains outcome (Fageria *et al.*, 2010). Ramos *et al.*, 1999 indicated that accompaniment the addition of basal potassium application to foliar K_2O spray twice in specific stages (the end of tillering and panicle initiation) produced the best component of the crop against control treatment. On the other hand, cultivation under alkaline conditions converted K from exchangeable to non-exchangeable form so, the potassium fertilizers became unavailable to root plants (Jothi *et al.*, 2019). Hence, accompaniment K soil application with foliar application in suitable concentration may be maximized utilization efficiency and ensure that the fertilizer synchronizes with plant needs in various stages. These results are in agreement with Awan *et al.* (2007), Metwally and Gharib (2011), Zayed *et al.* (2011) and Okasha *et al.* (2019).

Grain yield

Data documented in Table 4 clarified that both soil and foliar application of potassium fertilizer had a substantial influence on biological and grain yields in both seasons. The treatment of K_{11} rendered a remarkable outweighs compared to other treatments and there wasn't a significant difference between it and the treatment of K_{10} in both cultivated seasons.

Table 4. Influence of different potassium treatments on the grain yield, biological yield, and harvest index of Giza179 rice variety during the 2018 and 2019 seasons.

Term	B_1 Kg/ha	B_2 Kg/ha	F.C (%)	Biological yield (t/ha)		Grain yield (t /ha)		Harvest index (HI)	
				2018	2019	2018	2019	2018	2019
K_0	-	-	-	21.54	21.28	8.52	8.31	41.45	40.11
K_1	-	-	0.5	21.78	21.44	8.64	8.37	41.51	40.18
K_2	-	-	1.0	21.83	21.52	8.86	8.43	41.52	40.24
K_3	-	-	1.5	22.11	21.70	8.93	8.71	41.61	40.37
K_4	50	-	-	22.90	22.53	9.42	9.30	42.17	41.89
K_5	50	-	0.5	23.16	22.81	9.54	9.51	42.23	42.03
K_6	50	-	1.0	23.43	23.12	9.73	9.64	42.58	42.24
K_7	50	-	1.5	23.75	23.38	10.08	9.87	42.75	42.42
K_8	25	25	-	23.87	23.44	10.11	9.92	43.21	42.51
K_9	25	25	0.5	24.10	23.81	10.13	9.91	43.36	42. 57
K_{10}	25	25	1.0	24.36	24.00	10.53	10.21	43.57	42.71
K_{11}	25	25	1.5	24.51	24.34	10.61	10.42	43.72	42.83
LSD 5%				1.9	1.4	0.3	0.2	0.2	0.6

B_1: the first basal batch, B_2: the second basal batch, F.C: foliar concentrations.

This superiority may due to the tremendous action of potassium continuous supply which reflected on enhancement yield attributes so obtainment of high grain yield. It is worth to note that K uptake during the early vegetative stages is faster and active compared to other nutrients uptake. Hence, applying K fertilizers in both prior sowing and early periods of the plant life cycle is capable to enhance fertile tillers number that consequently optimizing the grain yield outcome (Dunn *et al.*, 2005). On the other hand, the sustainability of potassium addition causes encouraging starch production which is attributed to K-mediated carbohydrate metabolism and rather also to the transporter action of photosynthetic and sucrose inside plant tissue (Beringer, 1978 and Dunn *et al.*, 2005). The probable reason for high grain yield due to the collective action of both soil and foliar K application on obtaining highly number of both fertile tillers and filled grains/panicle and heaviest grain weight. Biological yield increased progressively up to the treatment of K_{11} but this treatment gave identical statistically with K_{10}, K_9, K_8, K_7, K_6, K_5, and K_4 in the 2018 season and with K_{10}, K_9, K_8, K_7, K_6, and K_5 in 2019 season. Inversely, control treatment rendered the lowest value of both biological and grain yields without significant difference with those of K_1, K_2, and K_3 in both cultivated season. A prior study by Awan *et al.,* 2007 stated that apportioning of soil potassium dosage leads to enhancement of grain magnitude outcomes. Noteworthy, accompaniment both soil and foliar potassium application work on heightening both grain and straw yield productivity but the foliar application only did not represent any noticeable increase as indicated by Metwally and Gharib (2011). These implications are in line with those of Awan *et al.* (2007), Metwally and Gharib (2011) and Atapattu *et al.* (2018).

E-2- Grain quality

Data in Tables 5 and 6 elucidate the effect of various potassium applications on the grain dimension which included, grain length (L) (mm), grain width (W) (mm), grain thickness (mm), and grain shape (L/W ratio). The highest grain length, grain width, grain thickness, and grain shape were rendered by K_{11} treatment in both seasons. However, no significant difference was observed in the grain dimension under several treatments. These findings are in line with those reported by Atapattu *et al.* (2018).

As for milling recovery characteristics, the results in Table 5 reveal that the various potassium treatments caused a significant effect on both the hulling, milling, and broken rice percentage in the 2018 and 2019 seasons. The highest value of the hulling percentage of Giza179 was obtained from the treatment of K_{11} treatment without significant difference from those of K_{10}, K_9, K_8, and K_7 treatments in the 2018 season. Whilst, both K_{10}, K_9, K_8 gave statistically identical in the 2019 season. Milling percentage (%) increased progressively up to using K_{11} treatment without significant difference between it and K_{10} treatment in both cropping seasons. The increase in hulling percentage (%) and milling percentage (%) under various potassium treatments might be attributed to the healthier plant uptake varietal nutrient (macro and micronutrients) resulted in maximizing brown and milled grains and minimize hull thickness under potassium fortification (Metwally and Gharib 2011 and Zayed *et al.,* 2011). Concerning the head rice percentage, a meaningful change was witnessed in head rice percentage (%) by the effect of K treatments (Table 7). The treatment of K_{11} rendered maximal head rice percentage without a significant difference with K_{10} treatment. Whilst, control treatment (without any K treatment) the least value of head rice with conformity statistic with K_1, K_2, and K_3 treatments in both seasons. The influence of dividing K fertilizer as soil and foliar application leads to replenishing and prolonging potassium presence up to the reproductive phase, consequently achieving active translocation and distribution of carbohydrates to emerging grains (Yang *et al.*, 2004). Accordingly, a benign accumulation of starch granules was accrued inside grain endosperm and impressive head rice percentage outcomes were going to be a logical result (Wang *et al*., 2004). These implications were in harmony with Atapattu *et al.* (2018) and Okasha *et al.* (2019).

Table 5. Influence of different potassium treatments on the Grain length (L) (mm), grain width (W) (mm), grain thickness (mm) of Giza179 rice variety during the 2018 and 2019 seasons.

Term	B_1 Kg/ha	B_2 Kg/ha	F.C (%)	Grain length (mm) 2018	Grain length (mm) 2019	Grain width (mm) 2018	Grain width (mm) 2019	Grain thickness (mm) 2018	Grain thickness (mm) 2019
K_0	-	-	-	5.10	5.00	2.31	2.28	1.75	1.73
K_1	-	-	0.5	5.12	5.05	2.32	2.31	1.77	1.73
K_2	-	-	1.0	5.14	5.08	2.34	2.32	1.80	1.76
K_3	-	-	1.5	5.20	5.15	2.37	2.35	1.81	1.78
K_4	50	-	-	5.38	5.28	2.42	2.36	1.85	1.83
K_5	50	-	0.5	5.42	5.27	2.43	2.38	1.86	1.85
K_6	50	-	1.0	5.45	5.30	2.45	2.40	1.89	1.86
K_7	50	-	1.5	5.46	5.37	2.47	2.42	1.91	1.90
K_8	25	25	-	5.45	5.36	2.45	2.43	1.88	1.86
K_9	25	25	0.5	5.50	5.45	2.48	2.47	1.91	1.89
K_{10}	25	25	1.0	5.57	5.51	2.52	2.49	1.94	1.92
K_{11}	25	25	1.5	5.63	5.55	2.52	2.50	1.95	1.94
LSD 5%				0.08	0.03	0.02	0.01	0.02	0.03

B_1: the first basal batch, B_2: the second basal batch, F.C: foliar concentrations.

Data in Tables 7 and 8 showed the different responses to various soil and foliar application methods on cooking and eating quality characteristics. Amylose content (%), gel consistency (GC), gelatinization temperature (GT), and kernel elongation (%) characteristics were witnessed varying impacts under various studied potassium treatments. Amylose content (%) increased progressively by applying K fertilizers. The treatment K_{11} recorded the highest content of amylose which statistically similar to K_{10}, K_9, K_8, K_7, K_6, and K_5 treatments in the 2018 season and with K_{10}, K_9, K_8, and K_7 treatments in the 2019 season. The lowest amylose content was shown under control treatment respectively in both seasons. However, there wasn't a statistical difference between K_0 and all individual foliar applications (K_1, K_2, and K_3) in both growing seasons. As for gel consistency (GC), a significant decrease was illustrated in GC by applying potassium application. The highest value of GC represents under the control treatment (K_0) without significant difference with those K_1, K_2, and K_3 treatments in both seasons. Whereas, the lowest value was obtained from K_{11}treatment without significant difference among K_{11}, K_{10}, K_9, K_8, K_7, K_6, K_5, and K_4 in the 2018 and 2019 seasons. It was responsible to assume that these implications because of the immense role of potassium fortification in spurring physiological starch synthesis processes especially amylose content (Rawat *et al.*, 2016). Grain amylose content has a negative correlation with gel consistency (stickiness values) consequently, kernels tend to cooked dry and separate or by another means becomes fluffy. These results are well supported by Juliano (1985) and Khatun *et al.* (2003). Concerning gelatinization temperature (GT) and kernel elongation, no significant difference was rendered under all studied treatments in the 2018 and 2019 seasons. These findings are agreed with the results indicated by Atapattu *et al.* (2018).

Table 6. Influence of different potassium treatments on the grain shape (L/W ratio), hulling percentage (%), and milling percentage (%) of Giza179 rice variety during the 2018 and 2019 seasons.

Term	B_1 Kg/ha	B_2 Kg/ha	F.C (%)	Grain shape (L/W ratio) 2018	Grain shape (L/W ratio) 2019	Hulling percentage (%) 2018	Hulling percentage (%) 2019	Milling percentage (%) 2018	Milling percentage (%) 2019
K_0	-	-	-	2.20	2.19	78.70	77.83	70.36	69.86
K_1	-	-	0.5	2.21	2.19	78.75	77.91	70.52	70.10
K_2	-	-	1.0	2.21	2.19	78.88	78.01	70.58	70.19
K_3	-	-	1.5	2.22	2.21	79.12	78.11	70.63	70.24
K_4	50	-	-	2.22	2.21	80.22	79.40	70.74	70.32
K_5	50	-	0.5	2.23	2.22	80.34	79.46	71.38	70.94
K_6	50	-	1.0	2.23	2.22	80.51	79.68	71.43	71.13
K_7	50	-	1.5	2.24	2.23	80.64	79.82	71.62	71.35
K_8	25	25	-	2.23	2.22	80.70	79.77	71.67	71.40
K_9	25	25	0.5	2.23	2.23	80.94	80.11	71.80	71.62
K_{10}	25	25	1.0	2.24	2.23	81.10	80.32	73.18	71.81
K_{11}	25	25	1.5	2.24	2.23	81.17	80.43	72.22	71.96
LSD 5%				0.01	0.01	0.5	0.3	0.3	0.2

B_1: the first basal batch, B_2: the second basal batch, F.C: foliar concentrations.

Data in Tables 7 and 8 rendered the different responses of cooking and eating quality characteristics to various soil and foliar application methods. Amylose content (%), gel consistency (GC), gelatinization temperature (GT), and kernel elongation (%) characteristics were witnessed varying impacts under various studied potassium treatments. Amylose content (%) increased progressively by applying K fertilizers. The treatment K_{11}recorded the highest content of amylose which statistically similar to K_{10}, K_9, K_8, K_7, K_6, and K_5 treatments in the 2018 season and with K_{10}, K_9, K_8, and K_7 treatments in the 2019 season. The lowest amylose content was shown under control treatment respectively in both seasons. However, there wasn't a statistical difference between K_0 and all individual foliar applications (K_1, K_2, and K_3) in both growing seasons.

Table 7.Influence of different potassium treatments on the head rice percentage (%) and amylose content (%) of Giza179 rice variety during the 2018 and 2019 seasons.

Term	B_1 Kg/ha	B_2 Kg/ha	F.C (%)	Head rice percentage 2018	Head rice percentage 2019	Amylose content 2018	Amylose content 2019
K_0	-	-	-	58.64	57.28	17.58	17.33
K_1	-	-	0.5	59.04	57.36	17.90	17.39
K_2	-	-	1.0	58.94	57.67	17.96	17.53
K_3	-	-	1.5	59.10	57.92	18.33	17.72
K_4	50	-	-	59.25	58.84	18.81	18.39
K_5	50	-	0.5	61.51	60.11	19.15	18.44
K_6	50	-	1.0	62.23	60.63	19.23	18.62
K_7	50	-	1.5	62.86	61.04	19.29	18.74
K_8	25	25	-	63.67	62.18	19.31	18.71
K_9	25	25	0.5	63.76	62.31	19.38	18.76
K_{10}	25	25	1.0	64.86	63.10	19.46	19.05
K_{11}	25	25	1.5	65.10	63.72	19.62	19.13
LSD 5%				0.7	0.7	0.3	0.3

B_1: the first basal batch, B_2: the second basal batch, F.C: foliar concentrations.

Table 8. Influence of different potassium treatments on gel consistency (GC), gelatinization temperature (GT), and kernel elongation (%) of Giza179 rice variety during the 2018 and 2019 seasons.

Term	B_1 Kg/ha	B_2 Kg/ha	F.C (%)	Gel consistency (GC) 2018	Gel consistency (GC) 2019	Gelatinization temperature (GT) 2018	Gelatinization temperature (GT) 2019	Kernel elongation (%) 2018	Kernel elongation (%) 2019
K_0	-	-	-	91.96	92.52	5.45	6.28	54.51	52.74
K_1	-	-	0.5	91.92	92.46	5.32	6.23	54.54	52.80
K_2	-	-	1.0	91.84	92.41	5.20	6.18	54.64	52.86
K_3	-	-	1.5	91.66	92.32	5.13	6.11	54.71	52.94
K_4	50	-	-	88.69	90.10	4.88	5.76	54.39	53.52
K_5	50	-	0.5	88.52	89.83	4.83	5.68	54.45	53.64
K_6	50	-	1.0	88.38	89.67	4.77	5.63	55.63	53.85
K_7	50	-	1.5	88.25	89.52	4.69	5.57	54.76	53.91
K_8	25	25	-	88.61	89.79	4.85	5.72	54.43	53.60
K_9	25	25	0.5	88.48	89.55	4.78	5.58	54.58	53.58
K_{10}	25	25	1.0	88.32	89.41	4.72	5.47	55.73	53.71
K_{11}	25	25	1.5	88.16	89.38	4.66	5.41	55.91	54.83
LSD 5%				1.3	1.1	0.14	0.17	0.9	0.6

B_1: the first basal batch, B_2: the second basal batch, F.C: foliar concentrations.

As for gel consistency (GC), a significant decrease was illustrated in GC by applying potassium application. The highest value of GC represents under the control treatment (K_0) without significant difference between it and K_1, K_2, and K_3 treatments in both seasons. Whereas, the lowest value was obtained from K_{11}treatment without significant difference among K_{11}, K_{10}, K_9, K_8, K_7, K_6, K_5, and K_4 in the 2018 and 2019 seasons. Concerning gelatinization temperature (GT) and kernel elongation, no significant difference was rendered under all studied treatments in the 2018 and 2019 seasons. These findings are agreed with the results indicated by Atapattu *et al.,* (2018).

Seed Technology characteristics

The influence of different potassium treatments exhibited a significant effect on seed technology characteristics results, i.e. plumule length, root length, seedling length germination %, and seedling vigor index (SVI) in both seasons (Table 9). The treatment K_{11} recorded the highest plumule length, root length, seedling length which statistically similar to K_{10}, K_9, K_8, K_7, K_6, and K_5 treatments in the 2018 season and with K_{10}, K_9, K_8, K_7, K_6, K_5, and K_4 treatments in the 2019 season. The lowest plumule length, root length, seedling length were shown under control treatment in both seasons. However, there wasn't a statistical difference between K_0 and all individual foliar applications (K_1, K_2, and K_3) in both growing seasons. Increased seedling growth performance in rice seedlings is due to cell division and elongation. These results are well supported by (Ali *et al.,* 2020).

Germination percentages and seedling vigor index (SVI) were significantly differed by different potassium treatments in both seasons. However, the treatments of K_{11}, K_{10}, and K_9 gave the best results in this study .Probably, these results due to raising the activity of photosynthesis of leaves at the long different growth stages, particularly during seed filling stage. Hence, high photosynthesis during grain filling stage ensured more nutrients translocation to the developing seeds. The high accumulation of metabolites in seeds may be influenced by its physiological quality. Also, potassium assists in seed germination by initiating the rapid imbibition of water, and it also facilitates other physiological processes, potassium salts have been thoroughly studied as good catalysts for improving seed germination and the emergence rate. Therefore, it can be concluded that K has an effective regulatory role in seed germination and emergence (Hasanuzzaman *et al.,* 2018).

Data in Table 10 represent the different responses of grain quality characteristics to various soil and foliar application methods.

Table 9. Influence of different potassium treatments on the plumule length, root length, seedling length germination %, SVI of Giza179 rice variety during 2018 and 2019 seasons.

Term	B_1 Kg/ha	B_2 Kg/ha	F.C (%)	Plumule length (cm)		Root length (cm)		Seedling length (cm)		Germination (%)		SVI	
				2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
K_0	-	-	-	6.14	6.67	5.71	5.90	11.72	12.16	82.8	82.0	09.7	09.9
K_1	-	-	0.5	6.30	6.73	5.84	5.98	11.97	12.31	83.6	82.1	10.0	10.1
K_2	-	-	1.0	6.27	6.93	5.92	5.10	12.12	12.62	83.8	82.6	10.2	10.4
K_3	-	-	1.5	6.44	7.16	5.96	5.18	12.29	12.88	84.0	82.8	10.3	10.7
K_4	50	-	-	6.83	7.58	6.02	6.55	13.06	13.73	84.1	83.8	10.9	11.5
K_5	50	-	0.5	7.11	7.62	6.15	6.71	13.29	13.91	84.3	84.2	11.2	11.7
K_6	50	-	1.0	7.17	7.77	6.45	6.88	13.42	14.19	84.7	84.9	11.4	12.0
K_7	50	-	1.5	7.23	7.92	6.61	7.00	13.82	14.34	85.5	85.3	11.8	12.2
K_8	25	25	-	7.21	7.83	6.58	6.92	13.84	14.58	85.0	84.6	11.8	12.3
K_9	25	25	0.5	7.26	7.88	6.84	7.10	14.15	14.58	86.1	85.2	12.5	12.4
K_{10}	25	25	1.0	7.50	8.16	6.90	7.26	14.40	14.86	86.5	85.8	12.5	12.7
K_{11}	25	25	1.5	7.51	8.21	6.93	7.35	14.44	15.12	86.7	86.2	12.5	13.0
LSD 5%				0.8	0.8	0.5	0.3	0.4	0.6	1.7	2.1	0.7	0.8

B_1: the first basal batch, B_2: the second basal batch, F.C: foliar concentrations.

Table 10. Influence of different potassium treatments on the Protein content and total Carbohydrate of Giza179 rice variety during the 2018 and 2019 seasons.

Term	B_1 Kg/ha	B_2 Kg/ha	F.C (%)	Protein content		Total Carbohydrate	
				2018	2019	2018	2019
K_0	-	-	-	8.62	8.54	78.31	77.94
K_1	-	-	0.5	8.57	8.51	78.33	77.97
K_2	-	-	1.0	8.54	8.48	78.36	78.03
K_3	-	-	1.5	8.50	8.44	78.70	78.10
K_4	50	-	-	8.54	8.50	79.11	78.36
K_5	50	-	0.5	8.51	8.47	79.12	78.50
K_6	50	-	1.0	8.46	8.45	79.17	78.57
K_7	50	-	1.5	8.45	8.42	79.19	78.66
K_8	25	25	-	8.28	8.26	79.16	78.53
K_9	25	25	0.5	8.26	8.24	79.22	78.97
K_{10}	25	25	1.0	8.21	8.20	79.25	78.83
K_{11}	25	25	1.5	8.20	8.18	79.26	78.83
LSD 5%				0.07	0.08	0.3	0.6

B_1: the first basal batch, B_2: the second basal batch, F.C: foliar concentrations.

Protein content and total carbohydrates were witnessed varying impacts under various studied potassium treatments. The treatment of K_{11} gave the highest content compared with other treatments, where the lowest value was obtained when no K fertilizers were added (K_0) in both growing seasons. Despite the importance of potassium in protein formation, no significant difference in protein content was noted among all treatments. Probably, this result due to the decrease in protein content after it reaches its maximum limit after 10 days from flowering as indicated by Yoshida (1981).

The results indicated that K_{11} treatment had the highest value of total carbohydrate content in both seasons without significant difference between this treatment and K_{10}, K_9, K_8, K_7, K_6, K_5, and K_4 treatments in both seasons. Prolonged and adequate supplying of K nutrition enhances organic acid, soluble sugar and amino acid resulted in fortified cytoplasmic K concentration which directly increases carbohydrate content as indicated by Baskaran *et al.* (1985). These results are in line with those obtained by Yang *et al.,* 2004

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تحسين انتاجية الحبوب ومعايير جودتها للصنف جيزة 179 المبدور بواسطة اضافة السماد البوتاسى بطرق مختلفة

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أقيمت تجربتان حقليتان بالمزرعة البحثية – محطة البحوث الزراعية بسخا - كفر الشيخ - مصر الزراعة ومعمل قسم تكنولوجيا البذور بمركز البحوث الزراعية – الجيزة - مصر خلال موسمي 2018 و 2019. هدف الدراسة معرفة تأثير طريقة الإضافة الأرضية للسماد البوتاسي (صفر 50 كيلو جرام / هكتار دفعة واحدة والتقسيم على دفعتين 25 كجم قبل البدار و 25 كجم بعد 25 يوم من البدار) والرش بمحلول بوتاسيوم بتركيزات مختلفة (صفر ، 0.5 ، 1 ، 1.5 %) على الصنف جيزة 179 . تم إستخدام تصميم القطاعات كاملة العشوائية وتوزيع 12 معاملة لدراسة مكونات المحصول (طول النبات و عدد الفروع الحاملة للداليات وعدد الحبوب الممتلئة والفارغة بالدالية ووزن الدالية ووزن الألف حبة) و وزن محصول الحبوب والمحصول البيولوجي وكذلك دليل الحصاد . بالنسبة لصفات الجودة فقد تم دراسة أبعاد الحبة وصفات التبيض و نسبة البروتين والكربوهيدرات فى الحبوب و نسبة الأميلوز و درجة سيولة الجل ودرجة حرارة الجلتنة وإستطالة الحبة بعد الطهى. أعطت المعاملة التى تم فيها تقسيم السماد التقسيم على دفعتين بالإضافة للرش بمحلول بوتاسيوم بتركيز 1 % أفضل نتائج لمكونات المحصول وبالتالي أعلى محصول حبوب بنسبة 63. 12 ، 11.92% وتحسين كلا من نسبة الحبوب السليمة بنسبة 9.87 ، 29. 8 % ونسبة الأميلوز بنسبة 4.19 ، 4.02 وتقليل درجة سيولة الجل بنسبة 0.88 ، 0.59 % مقارنة بإستخدام التسميد البوتاسى كدفعة واحدة فقط . أظهر تأثير معاملات البوتاسيوم المختلفة تأثيراً معنوياً على نتائج صفات تكنولوجيا البذور. لم تظهر باقى صفات الجودة المدروسة اى تاثير معنوى تحت مستويات التسميد البوتاسى المختلفة وخلصت الدراسة الي أن إستخدام طريقة تقسيم السماد البوتاسى على دفعتين مع الرش بمحلول بوتاسى بتركيز 1% يمكن تطبيقة علي الصنف جيزة 179 لتحسين كلا من ناتج الجبوب وجودتها.