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Research Article

Effect of split application of nitrogen and potassium as well as spraying growth regulators on growth and yield attributes of hybrid rice

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Keywords:
Nitrogen, Potassium, growth regulators, application splitting and GA3.

Abstract:

Two field experiments were carried out during 2020 and 2021 summer seasons at the experimental farm of Research and training center in rice, FCRI, ARC, Egypt, to study the effect of split application of nitrogen and potassium as well as some growth regulators for some growth attributes of the female line of rice hybrid NO.1. Split-split plot design with three replicates was used. Results indicated that, adding N in three splits (N 20- 20-20kg) significantly surpassed the other two ones for plant height and leaf area index. Added N in two splits (N 30- 30kg) significantly exceeded the other splits for chlorophyll content, panicle exertion and flag leaf area. For application splits of potassium, the third split (K 9- 9- 7kg) had significantly higher than the other ones for plant height, chlorophyll content and flag leaf angle, while the second split (K12.5- 12.5kg) surpassed the others for flag leaf area and leaf area index. However, panicle exertion was significantly affected by the first split (K 25kg). Spraying GA3 had significantly higher values for plant height and leaf area index, while spraying with IAA significantly surpassed the other two growth hormones for chlorophyll content, panicle exertion and grain yield. However, ascorbic acid (AA) significantly exceeded the others for flag leaf area only. Plant height, chlorophyll content and panicle exertion were significantly affected by first and second order interactions except for panicle exertion where the first order N x K interaction was only observed. It was concluded Finally could be concluded that, the desirable treatment was adding the nitrogen in three splits N 20-20-20, while, the potassium in two splits and apply the GA3 with (30g/ha.) to produced highly seed yield (t/ha.)

1. Introduction

Nitrogen is the most essential nutrient for rice production. Nitrogen contributes about 20% of the rice yields out of total application of nitrogen, phosphorous and potassium fertilizers. Most of the nitrogen applied through fertilizer is lost from soil by leaching, volatilization, surface runoff, and de-nitrification. Leaching loss of N occurs in the form of NO3 and NH4 from rice fields and the extent of loss by NO3-N is more than 90% (Sahu and Samant, 2006). Application of N fertilizers at higher doses cause higher leaching loss. Leaching losses can be minimized by split application of nitrogenous simple fertilizer, application of complex/ compound fertilizers in granular form, keeping the rice field's alternate wetting and drying, addition of organic matter to soil. Considering at the various types of losses of nitrogen, the nitrogen use efficiency of rice soil can be increased through the right choice of source, right dose, right time and right method of application of N fertilizer along with proper water management practices (Sahu and Samant, 2006**)**. However, the right time of split application of N fertilizer for maximum yield is not studied well in the study area. This research was, therefore, conducted to determine the appropriate nitrogen fertilizer application timing for hybrid rice. Plant growth regulators (PGRs) are organic compounds that can promote, inhibitor modify physiological processes in plants. Tadesse et al., (2017) growth regulators like GA_3, NAA and chemicals like K_2PO_4 along with boron as foliar spray found to improve panicle emergence, seed set percent and seed yield in hybrid rice seed production. Application of GA_3 at 5 per cent panicle emergence is recommended in hybrid seed production, to improved plant height, flag leaf angle, panicle exertion, pollination, synchronization in flowering and seed set percentage **Wu *et al*., (2008)**. Gibberellins (GA_3) are a large family of natural products that regulate many developmental processes in plants, including seed germination. Stem elongation, and induction of flowering. Over the years, more than a hundred GA_3 have been identified from organisms, amongst, which only few compounds are available in large quantities such as the relatively cheap natural derived Phyto hormone named gibberellic acid (GA_3).

Also, potassium is one of the three major plant nutrients; the application to rice crop has received least attention, even though potassium accounts for a greater share of total nutrients removed from the soil by rice crop. Response of rice to applied potassium is highly variable (Vidya, 2011). Potassium plays an important role in rice plant nutrition. Continuous application of potassium improves all soil properties and perhaps the use of higher rates of nitrogen, application of potassium along with nitrogen has become very necessary due to intensive agriculture with high yielding varieties. Therefore, the present study aimed to study the effect of apply the nitrogen and potassium splitting, as well, growth regulators on hybrid rice seed production of the parental lines to Egyptian hybrid No. 1.

Ascorbic acid, an abundant, relatively small molecule in plants, plays multiple roles in plant growth, functioning in cell division, cell wall expansion, and other developmental processes Ascorbic acid has effects on many physiological processes including the regulation of growth and metabolism of plants (Foyer, 1993**)**. Ascorbic acid is small, water-soluble molecule, which acts as a primary substrate in the cycling pathway for detoxification and neutralization of superoxide radicals and singlet oxygen, ascorbic acid is a key substance in the network of plant antioxidants, including glutathione and enzymatic antioxidants that detoxify H_2O_2 to counteract oxygen radicals produced by the mehlerreaction and photorespiration (Noctor and Foyer, 1998; Smirnoff, 1996). These free radicals may cause oxidative stress resulting in cellular damage by oxidation of lipids, proteins and nucleic acids so ascorbic acid protect metabolic processes, (Noctor and Foyer, 1998). Ascorbic foliar application increased the yield of rice crop, (Taha, 2008; Gharib et al., 2011).

2. Materials and Methods

Two field experiments were conducted during the two successive summer seasons of 2020 and 2021, at an experimental farm of Research and Training Center in Rice, Sakha, Kafr El-Sheikh, Field Crops Research Institute, Agriculture Research Center (ARC) Egypt, to study the effect the application time of nitrogen and potassium as well as plant growth regulators on some, growth attributes, of the female line. The seed of the parental lines for the Egyptian hybrid rice No.1, were used. A split-split plot design was used where the main plot was occupied by nitrogen fertilizer, the sub-plot was devoted by potassium fertilizer, while the sub-sub plot was distributed by growth regulators of hormones with three replications. The date of sowing for the female line IR69625A was on 20^{th} April, while the male line (Giza 178) was sown with three intervals, the first was in 27^{th} April, the second in 30^{th} April and third in 3^{th} May, respectively, to get complete synchronization of flowering based on the growth duration in the previous season. The remaining cultural practices were done according to RRTC (2019).

2.1. Cultural practices:

2.1.1. The nursery: The seed rate of the parental lines was 15kg/ha. of female + 5kg/ha. of male were soaked in water for 24 hours, then drained and incubated for 48 hours to hasten early germination. Pre-germinated seeds were uniformly broadcast in the nursery on 20^{th} April for female line, but for the male parent starting from 27^{th} April up to 3^{th} May during 2020 and 2021 seasons. The other cultural practices were applied as recommended by (RRTC, 2019).

2.1.2. The permanent field: The experimental sites were prepared by twice plowing and harrowing, then carefully dry and wet leveled. Each sub-plot was fertilized with 37kg P_2O_5/ ha. in the form of calcium super phosphate (15.5% P_2O_5) during soil preparation. Nitrogen in the form of urea (46 % N) at the rate of 150 kg N/ fad. was added in different split doses, for K2O added in different times. Zinc sulfates (22 % $ZnSo_4$) at the rate of 23.8kg/ha. was added after pudding. Thirty days old seedling were pulled and transplanted to the permanent field, then transplanted regularly in the sub-plots at 15×15cm distances between hills in rows and 20×20cm for male parented and 30cm between female and male parent apart, at the rate of 1–2 seedling/hill in all field experiments in both seasons. The herbicide Saturn 50% at the rate of 5liters hectare-1 mixed with enough sand to make it easy for homogenous distribution was applied 4 days after transplanting for female parent into 3cm water depth and kept without either flushing or irrigation until all the water in the field was absorbed to increase the efficiency of the herbicide. The sub-plot size was 12 m^2 (3 x 4 m). Seedlings were carefully pulled from the nursery after 30 days from seeding and transferred to the permanent field. Seedlings were handling transplanted in hills at the rate of 2-3 seedlings/hill. The other usual agricultural practices of growing rice were performed as the recommendation of Rice Research and Training Center (RRTC, 2019).

2.1.3. Factors used:

A-Nitrogen fertilizers: Three nitrogen application splits were added in the rate of 150 kg N/fed., as urea 46% N: 1) First time, all at 20 days from (transplanting (N_1). 2) Second time, half at basal (B) + half at 20 days from (transplanting (N_2). 3) Third time, one-third at basal (B) + one-third at 20 days from transplanting + one-third at 40 days from transplanting (N_3).

B-Potassium fertilizers: The sub plots were occupied by the three treatments of potassium applications at the rate of (25 kg K_2O/fed., as potassium sulphate 48% K_2O). 1) First time, as basal application (25 kg) fed., (K_1). 2) Second time, half (12.5kg) was added at basal (B) and half (12.5kg) after 30 days from transplanting (K_2). 3) Third (time 9 kg) fed., was added at basal (B) and (9 kg) fed after 30 days from transplanting and (7kg) fed after 50 days from transplanting (K_3)

C- Growth regulators: The sub-sub-plots were devoted by three treatments of growth regulators (Leave foliar) spraying as: 1) Indole Acetic Acid (IAA) (30 g/ha.) (100% concentration) (GR_1). 2) Ascorbic Acid (AA)(30g/ha.)(100%concentration).(GR_2). 3)Gibberellins (GA_3) (30 g/ha.) (100% concentration). (GR3). (Frist at 40% concentration at 15% from flowering and the 60% concentration as the second at 45% from flowering).

D- Supplementary Pollination: Supplementary pollination is artificially shaking the canopy of the pollen parent at flowering to distribution of pollen grains of Giza 178-R line. It was done three times every day (starting from 10-12 o'clock at the morning) from being flowering of Giza 178 R line.

E- Synchronization of flowering: Determination of growth duration from seeding to flowering was used for IR 69625-A line and Giza 178-R line to adjust flowering date between both parents in both seasons.

F- Prediction of heading date: Heading date is predicted on the basis of panicle initiation of main tiller, which begins at maximum tiller ring stage in all rice cultivars. The culm is the slit length wise from base up to the top of tiller. Slit opened immediately above the nodal portion.

Studied Characters: The data were recorded according to standard evaluation system of IRRI 2008, for all studied characters as: plant height(cm), panicle exertion, flag leaf area, leaf area index, total chlorophyll content and grain yield.

Statistical analysis: All data collected were subjected to analysis of variance according to **Gomez and Gomez (1984)**. Treatment means were compared by Duncan's Multiple Range Test, (Ducan, 1995). All statistical analysis was performed using analysis of variance technique by means of **"COSTAT"** computer software package.

3. Results

3.1 Growth characters:

1-Plant height: Data presented in Table (1) indicated that, increasing splits of nitrogen fertilizer significantly affected plant height during both seasons. The highest values for plant height were (112.11 – 115.77 cm) produced by adding nitrogen on three equal splits N 20-20-20kg. On the other hand, the lowest values were obtained from applying the nitrogen fertilizer in one split (25-kg), indicated that, apply the nitrogen fertilizer in three splits will maintain on the soil fertilizer during growth period. Moreover, the increase of plant height in response to application of N fertilizer was probably due to enhanced arability of N which resulted in more leaf area (Mandel et al., 1992) that in time enhanced photo assimilates and thereby resulted in more dry matter accumulation (Ropp and Hubner, 1995). For the potassium application recorded highest values with apply potassium fertilizer in three times compared to other treatment, indicated to apply the potassium sulfate will enhancement the response to mineral elements and increase the growth rate at tillering stage during the two seasons. leave foliar (growth regulators) with three sources (IAA, Ascorbic acid & GA_3) recorded that, maximum values were (112.44-115.55), with GA_3 during two seasons, the changes in plant height might be due to the action of GA_3 in increasing stem elongation of parental lines. The similar results were obtained by (Prabagacan and Pomuswany, 1997) were they revealed that, the foliar application of GA_3 at early growth stages resulted in the maximum plant height, (Sharma et al. 2009), where they found that, the application of GA_3 at the rate of 70 g ha^{-1} was optimum for increased seed setting and seed yield in cytoplasmic-genetic male-sterile (CGMS) parent. Parihar et al., (2012) found that the maximum plant height was recorded with the application of GA_3 at the rate of 60g ha^{-1} followed by GA_3 in the rate of 45g ha^{-1}. El-Ekhtyar (2014) reported that, plant height of rice plants reached its maximum means when rice plants received its potassium requirement into four equal doses. Tadosse et al**.,** (2017) revealed that, the increase in plant height in response to application of N fertilizer was probably due to enhanced availability of N which resulted in more leave area that in turn enhanced photo assimilates and thereby resulted in more dry mater accumulation. Ramesh et al. (2019) indicated that, the application of GA_3 at the rate of 25g ha^{-1} had significantly registered the highest plant height. Mani et al., (2020) indicated that, plant height increased significantly by application of potassium over no potassium and control, the maximum plant height was observed in the treatment receiving three split applications of potassium followed by two splits. Seema and Singh (2021) found a significant increase of plant height when plants received K in three equal splits over the control.

2-Chlorophyll content: For Chlorophyll content as shown in Table (1), the highest values were obtained from adding nitrogen fertilizer in two splits (30 and 30kg), which recorded (38.45 and 36.81), in the two seasons, respectively. While, the potassium fertilizer was applied in three splits (9-9-7 kg) which recorded the best values (38.53–35.66), in the two seasons. Moreover, apply the leave foliar (growth regulators) in three sources (IAA, AA & GA_3) recorded the significantly higher value with IAA (38.21-35.77) during two seasons, with no significant differ than GA_3 in the second season. This might indicate that, the balance of fertilizer between the nitrogen and potassium plus growth regulator will enhance the crop growth rate then increase the chlorophyll content then yield components. Elankavi et al., (2009) found that the application of phytohormones increased the chlorophyll content mainly by delaying the leaf senescence in rice (Debata and Morthy, 1981). El-Ekhtyar (2014) stated that potassium splitting significantly affected chlorophyll content measured at heading in both studied seasons. Coutan et al., (2018) studied the effects of plant growth regulators on chlorophyll content in leaves of rice plant, they found that, maximum increase of chlorophyll content at different growth stages with foliar application of hormones.

3- Panicle exertion%: For panicle exertion the desirable values were obtained from adding nitrogen fertilizer in two split (30 and 30kg), the highest values were (20.62 and 21.55) in the two seasons. as shown in Table (1). While for the potassium fertilizer when applied in one dose (25kg) was recorded the best values (20.62 – 21.44). Moreover, applied the leave foliar (growth regulators) with three resource (IAA, AA & GA_3) the maximum values recorded with IAA (20.59-21.22) during the two seasons. **Tiwan *et al*. (2011)** indicated that, the application of GA_3 led to increases of influences panicle exertion, spikelet opening angle and other floral traits which increases outcrossing rate of CMS lines leading higher yield. Parihar et al. (2012) pointed out that, in CMS line (IR 58025 A) an overage of 66.67% panicle exertion was observed. Application of GA_3 at the rate of 45g ha^{-1}, 60g ha^{-1} and 30g ha^{-1} significantly increased panicle exertion.

The interactions among applied different levels of nitrogen, potassium and growth regulators affected significantly plant height and panicle exertion in both seasons under study, while the interactions were not affected the chlorophyll content in both seasons. Data in Table (2) showed that, the interactions between nitrogen and potassium application had a significant effect on plant height in the two seasons the significantly desirable values (114.66-119) were recorded with applied the nitrogen in two splits N 30-30kg and the potassium in three splits(K_2SO_4 9-9-7kg) compared to other treatments during the two seasons which might indicated that apply of potassium in three times will increase the nitrogen response then increase the nitrogen use efficiency and subsequent increase the crop growth rate and seed yield/unit area.

Table (1): The effect of nitrogen, potassium fertilizers, hormones and their interactions on plant height and panicle exertion of parental lines during 2020 and 2021 season.

Factors	Plant height		Chlorophyll content		Panicle exertion	
Main-plots	**2020**	**2021**	**2020**	**2020**	**2021**	**2021**
Nitrogen (N)						
N_1	111.18 b	111.08 b	34.42 b	37.76 b	18.11 c	19.22 c
N_2	111.77 b	115.22 a	36.81 a	38.45 a	20.62 a	21.55 a
N_3	112.11 a	115.77 a	33.71 c	37.27 b	19.70 b	20.96 b
F-Test	**	**	**	**	**	**
Sub-plots						
Potassium (K)						
K_1	111.77 b	112.74 b	33.93 b	37.45 b	20 a	21.44 a
K_2	111.40 b	112.66 b	35.35 a	37.5 b	19.22 b	20.22 b
K_3	113.88 a	116.77 a	35.66 a	38.53 a	19.20 b	20.07 b
F-Test	**	**	**	**	**	**
Growth regulators (GR)						
IAA	111.29 b	112.62 c	35.77 a	38.21 a	20.59 a	21.22 a
AA	111.33 b	114 b	34.31 b	37.11 b	19.66 b	20.33 b
GA_3	112.44 a	115.55 a	34.85 b	38.16 a	18.18 c	20.18 b
F-Test	**	**	**	**	**	**
Interaction						
N x K	**	**	NS	NS	**	**
N x GR	*	*	NS	NS	**	**
K x GR	**	**	NS	NS	NS	NS
N x K x GR	**	**	NS	NS	*	*

Table (2): The effect of the interaction between nitrogen and potassium splits application on plant height of female lines during 2020 and 2021 seasons.

N	Plant height					
	2020			2021		
	K			K		
	K_1	**K_2**	**K_3**	**K_1**	**K_2**	**K_3**
N_1	112.33 b	111 c	110.66 d	108.88 g	110.66 f	114 d
N_2	110 d	111.22 c	114.66 a	114 d	112.66 e	119 a
N_3	111 c	112 b	112.33 b	115.33 c	114.66 d	117.33 b

Table (3): The effect of the interaction between nitrogen splits and leave foliar for hormones on plant height of female lines during 2020 and 2021 seasons.

N	Plant height					
	2020			**2021**		
	GR			**GR**		
	IAA	**AA**	**GA_3**	**IAA**	**AA**	**GA_3**
N_1	111 c	111.33 c	112 b	113.66 e	108.88 h	111 g
N_2	111.88 c	110.66d	113.66 a	113.66 e	112.66 f	119.33 a
N_3	111 c	113.33a	111 c	114.66 c	116.33 b	116.33 b

Table (4): The effect of the interaction between potassium splits and leave foliar for hormones on plant height of female lines during 2020 and 2021 seasons.

K	Plant height					
	2020			**2021**		
	GR			**GR**		
	IAA	**AA**	**GA_3**	**IAA**	**AA**	**GA_3**
K_1	110.66 **d**	113.33 **a**	111.66 **c**	113.33 **c**	109.88 **e**	115 **b**
K_2	111.88 **c**	110.33 **d**	112 **b**	113 **c**	110.66 **d**	114.33 **bc**
K_3	111.33 **c**	113.66 **a**	110.33 **d**	115.66 **b**	117.66 **a**	117.33 **a**

Table (5): The effect of the interaction between nitrogen, potassium splits and leaves foliar for hormones on plant height of female lines during 2020 and 2021 seasons.

N	K	Plant height 2020 GR IAA	AA	GA3	2021 GR IAA	AA	GA3
N_1	K_1	112 b	109 c	115 ac	112 hi	104.66 m	110 hj
	K_2	108 cd	114 ad	111 bc	109 jk	108 jl	115 e
	K_3	113 ab	109 c	110 bd	120 ab	114 ef	108 K
N_2	K_1	112 b	108 cd	110 bd	112 hi	113 gh	117 bd
	K_2	114.66 ad	108 cd	111 bc	115 e	105 lm	118 bc
	K_3	109 c	116 ab	117 a	114 ef	120 ab	123 a
N_3	K_1	108 cd	115 ac	110 bd	116 be	112 hi	118 bc
	K_2	113 ac	109 c	114 ad	115 e	119 ac	110 hj
	K_3	112 b	116 ab	112b	113 gh	118 bc	121 ab

Table (6): The effect of the interaction between nitrogen and potassium splits on panicle exertion % of female lines during 2020 and 2021 seasons.

N	Panicle exertion 2020 K K_1	K_2	K_3	2021 K K_1	K_2	K_3
N_1	19.33 c	16 e	19 cd	19.66 d	17.66 e	20.33 cd
N_2	21.33 ab	20 bc	20.55 b	22.66 b	19.66 d	20.55 c
N_3	19.33 c	21.66 a	18.11 d	22b c	23.33 a	19.33 de

Table (7): The effect of the interaction between nitrogen split and leave foliar for hormones on panicle exertion % of female lines during 2020 and 2021 seasons.

N	Panicle exertion 2020 GR IAA	AA	GA3	2021 GR IAA	AA	GA3
N_1	18 ef	19.66 d	16.66 f	20 d	18 f	19.66 e
N_2	22.00 a	20.33 c	19.55 d	22.66 a	20.33 c	20.22 cd
N_3	21.77 b	19 de	18.33 e	21.33 b	22.33 ab	20.66 bc

Table (8): The effect of the interaction between nitrogen, potassium split and leave foliar of hormones on panicle exertion of female lines during 2020 and 2021 seasons.

N	K	Panicle exertion 2020 GR IAA	AA	GA3	2021 GR IAA	AA	GA3
N_1	K_1	21 bc	20 c	17 e	22e	19 fg	18 g
	K_2	15 f	17 e	16 ef	18 g	16 h	19 fg
	K_3	18 de	22 b	17 e	20 f	19 fg	22 e
N_2	K_1	23.66 a	20 c	21 bc	25.33 a	21 ef	22 e
	K_2	21 bc	20 c	19 cd	19 fg	20 f	20 f
	K_3	22 b	21 bc	18.66 d	23 be	20 f	18.66 fg
N_3	K_1	23 ab	20 c	15 f	20 f	24 b	22 e
	K_2	22 b	21 bc	22 b	23 be	25 ab	22 e
	K_3	20.33 c	16 ef	18 de	21 ef	19 fg	18 g

Data listed in Table (3) showed that, the interactions between nitrogen and leave foliar application had a significant effect on plant height, where its recorded the best values (113.66-119.33) with apply the nitrogen in two splits N 30-30kg, and the leave foliar of GA_3 during the two seasons. However, those results did not significantly differ than applying of N in three splits (20-20-20) and spraying ascorbic acid (AA) in the two seasons. This might have indicated that apply the nitrogen in two times will increase the nitrogen response then increase the nitrogen use efficiency plus apply the growth regulators will increase cell division for the plant height and seed yield/unit area.

Data in Table (4) showed that, the interactions between potassium and leave foliar application which had a significant effect on plant height, where it is recorded that the application of K either in one dose (25kg) or in three splits (9-9-7kg) when interacted with ascorbic acid (AA) gave the significantly highest values in the first season, while in the second season the application of K in three splits (9-9-7kg) when interacted with either ascorbic acid (AA) or GA_3 gave the significantly highest values of plant height**,** Quampah et al., (2011) mentioned that K fertilization helped enhance the crop performance in upland irrigation system. However, upland rice cropping practiced with K_2SO_4 fertilization improved water use efficiency of the most genotypes.

Data shown in Table (5) showed that, the second order interaction between nitrogen, potassium and leave foliar application had a significant effect on plant height, where its recorded the significantly optimum values with apply the nitrogen in two splits (N 30-30kg), when interacted with GA_3 both the seasons. However, the interaction of tree splits of N × two splits of K × IAA two splits of N × three splits of K × AA did not significantly differ in the first season and the interaction of N_2× N_3 × either AA or GA_3 and the interaction of N_2 × N_3 × GA_3 in the first season did not significantly differ with respect to plant height. Also, apply the potassium in three splits (K_2SO_4 9-9-7kg) and GA_3 as a foliar application (117-123) during the two seasons compared to other treatments. El-Ekhtyar et al., (2014) showed that, potassium and gibberellic acid applications could partially mitigate the harmful effects of stress condition on growth and productivity of the three tested rice cultivars.

Data drawn in Table (6) showed that, the interaction between nitrogen and potassium applications had significant effect on panicle exertion %, where its recorded the significantly optimum values (21.66-23.33) with apply the nitrogen in three splits (N 20-20-20 kg/fad.), and potassium in two splits (K_2SO_4 12.5-12.5 kg/fad.), during the two seasons, However, the interaction of N_2 × K_1 did not significantly differ than that the interaction of N_3 × K_2 in the first season with respect to panicle exertion. This might indicate that apply the nitrogen in three splits plus apply the potassium sulfate in two splits will increase the nitrogen response and consequence increase the nitrogen use efficiency and consequently increase the crop growth rate and panicle exertion %. Yajjala (2011) reported that, the application of 80 kg K_2SO_4 ha^{-1} in two splits (½ basal + ½ panicle initiation) performed better in realizing better growth, yield and yield attributes of rice.

Data listed in Table (7) showed that, the interactions between nitrogen and leave foliar application had a significant effect on panicle exertion %, where the significantly desirable values (22-22.66) were obtained with applying the nitrogen in two splits N 30-30kg, and leave foliar with IAA during the two seasons. This might indicate that apply the nitrogen plus growth regulators will increase the nitrogen response then the nitrogen use efficiency, as well as, increase the crop growth rate and panicle exertion %. Baksh et al., (2017), recorded that, maximum benefit can be achieved when indole acetic acid was applied in the rate of 80 ml ha^{-1} with fertilizer dose of nitrogen and phosphorous 80kg ha^{-1}.

Data drawn in Table (8) showed that, the interactions between nitrogen, potassium and leave foliar application had significant effect on panicle exertion %, where the significantly desirable values (23.66-25.33) were obtained with apply the nitrogen in two splits N 30-30kg, with apply the potassium in one split (K_2SO_4 25 kg) and spraying IAA as a foliar application during the two seasons, indicated that apply, the nitrogen and potassium in early stages will enhancement the seedling vigor then panicle exertion %. in the similar way of study by (Reddy *et al*., 2009), where they spray of NAA at the rate of 100 g ha^{-1} in combination with borax 0.1 % + KH_2PO_4, 0.2% which gave higher grain yields in rice hybrid, DRRH-1.

4- Flag leaf area: Data presented in Table (9) indicated that, the splits of nitrogen fertilizer significantly affected the flag leaf area during both seasons. The highest flag leaf area was (36.01 – 36.85) produced by adding nitrogen in two equal splits (N 30-30kg), Also, adding the potassium sulfate in two splits (K 12.5-12.5 kg), recorded the highest values (36.35 and 36.51), while, for leave foliar of hormones with three sources (IAA, AA and GA_3), showed that, the maximum values (37.91-35.64), were recorded with ascorbic acid during the two seasons. Ali et al., (2019) reported that, in the case of the application liming of potassium, the highest leaf area tiller-1 was found in those plants that received whole potassium at sowing time. It was followed by K application in two equal splits (at sowing and 30 DAS) and three splits ($^1/_2$ at sowing + $^1/_4$ at both 30 and 60 DAS). The lowest leaf area was noted in plots received K in four equal splits (at sowing, 30, 60 and 90 DAS).

5- Leaf area index: For leaf area index as shown in Table (9), indicated that, adding the nitrogen fertilizer in three splits (N 20- 20 -20 kg), recorded the significantly highest values (15.48 – 18.32) for the trait in view. While, potassium fertilizer when apply in two splits (12.5-12.5 kg), recoded the significantly maximum values (15.30–18.54) and for leave foliar (growth regulators) with three sources (IAA, AA and GA_3) showed, the maximum values (16.49 - 18.58) for the trait in question with GA_3 during the two seasons. **Elankavi *et al* (2009)** indicated that, the increase of leaf area index could be attributed to the increased functional leaf area and delayed leaf senescence (Chen et al., 1982).

6- Grain yield (t/ha.): Data presented in Table (9) showed that, increasing splits of nitrogen fertilizer significantly affected on seed yield in both seasons. The highest seed yield was produced by adding nitrogen on three equal splits. N 20-20-20kg, (3.18 and 3.24 t/h.,). On the other hand, apply potassium fertilizer in two splits recorded, the desirable values were (3.05 and 3.36 t/h.,), while, for leaf foliar (growth regulators) recorded the maximum value with GA_3 (3.10 and 3.22 t/h.,) during two seasons. EL-Ekhtyar (2014) showed that, grain yield was markedly affected by potassium split application. Potassium splitting into four equal doses gave the maximum mean of grain yield in both seasons. The minimum values of grain yield were recorded when rice plants received the applied potassium in one dose as basal application. Tadesse et al., (2017**)** indicated that, grain yield of the rice exhibited significant response to time of nitrogen fertilizer application (P<0.01). The highest grain yield was obtained at (T_4), applying 1/3rd of 25 days after sowing and 2/3rd at panicle initiation. Goutan et al., (2018) painted out that, grain yield significantly increased by the application of plant growth regulators. The maximum increased of grain yield was recorded with the application of IAA 50 ppm fallowed by lower dose of IAA 25 ppm over control. Ali et al (2019) indicated that, the higher grain yield was achieved in plots receiving whale K at sowing, followed by K applied in two equal splits (sowing + 30 DAS) and three splits (1/2 at sowing + 25 % both 30 and 60 DAS). Ramesh et al (2019) recorded that, the significantly higher grain yield was obtained by spraying GA3 at 25 g/ha-1. This might be attributed to the increased supply of photo synthetic material and its efficient mobilization giving rice to increased stimulation of yield attributes. Nand et al., (2020) stated that, application of potassium fertilizer increased grain yield under the treatment receiving three splits application of potassium (50 % at basal, 25 % at tilliring, 25 % at panicle), Sharma and Singh (2021) revealed that, the split application of K has significantly affected the grain yield, where the significantly higher grain yield was recorded at T6 where potash was applied in three equal splits (at basal, at 25 DAT and 45 DAT).

Table (9): The effect of nitrogen, potassium fertilizer splits and leave regulator of hormones with their interactions on flag leaf area, leaf area index and grain yield of parental ten lines during 2020 and 2021 seasons.

Factors	Flag leaf area		leaf area index		Grain yield (t/ha.)	
Main-plots	**2020**	**2021**	**2020**	**2021**	**2020**	**2021**
Nitrogen (N)						
N1	33.84 c	33.77 c	13.26 b	16.01 b	2.85 c	2.90 c
N2	36.01 a	36.85 a	15.01 ab	17.91 ab	3.00 b	3.05 b
N3	35.85 b	34.78 b	15.48 a	18.32 a	3.18 a	3.24 a
F-Test	**	**	**	**	**	**
Sub-plots						
Potassium (K)						
K 1	34.17 c	32.64 b	13.21 b	15.78 c	2.91 c	2.88 c
K 2	36.35 a	36.51 a	15.30a	18.54 a	3.05 a	3.36 a
K 3	35.17 b	36.25 ab	15.04ab	17.93 b	3.007 b	2.99 b
F-Test	**	**	**	**	**	**
Sub-sub-plots						
Growth regulators (GR)						
IAA	32.83 c	34.48 b	12.52 c	16.08 c	2.91 c	2.98 c
AA	37.91 a	35.64 a	14.74 b	17.59 b	2.96 b	3.02 b
GA3	34.95 b	35.28 ab	16.49 a	18.58 a	3.10 a	3.22 a
F-Test	**	**	**	**	**	**
Interaction						
N x K	NS	NS	**	**	**	**
N x GR	NS	NS	NS	NS	**	**
K x GR	NS	NS	*	*	**	**
N x K x GR	NS	NS	NS	NS	**	**

The interactions between different splits of nitrogen, potassium and growth regulators are not significant for flag leaf area and flag leaf angle except for leave area index for nitrogen and potassium splits interactions in both seasons, where the interactions were highly significant and potassium and growth regulators interactions in both seasons, where the interactions were only significant. Results listed in table (10) showed that, the interactions between nitrogen and potassium application in splits had significant effect on leaf area index, which recorded the significantly

Leaf area index, which recorded the significantly desirable values (18.15 and 20.94) with apply the potassium in two splits (K_2SO_4 12.5-12.5 kg), with spray the leaf

maximum values (19.08 and 20.43) with apply the nitrogen in two splits (N 30-30 kg), and the potassium in three splits (k2so4 9-9-7kg) during the two seasons, indicated to apply the potassium in different splits will increase the nitrogen response, then increase nitrogen use efficiency and crop growth rate and leaf area index.

Results shown in Table (11) indicated that, the interactions between potassium splits and leaf foliar application had significant effect on

foliar of GA3 during the two seasons compared to the other interactions.

Table (10): The effect of the interaction between nitrogen and potassium splits on leaf area index of female lines during 2020 and 2021 seasons.

N	leaf area index					
	2020			2021		
	K			K		
	K 1	K 2	K 3	K1	K2	K3
N 1	10.76 g	15.89 c	13.14 ef	10.63 h	16.99 f	15.48 g
N 2	11.83 f	15.54 cd	19.08 a	19.70 b	18.56 c	20.43 a
N 3	17.05 b	14.47 d	13.50 e	17.00 ef	20.09 ab	17.88 e

Table (11): The effect of the interaction between potassium splits and leave foliar of hormones on leaf area index of female lines during 2020 and 2021 seasons.

K	leaf area index					
	2020			2021		
	GR			GR		
	IAA	AA	GA3	IAA	AA	GA3
K1	11.75 f	14.67 c	13.22 de	14.76 h	15.78 g	16.79 f
K2	13.56 d	14.24 cd	18.15 a	15.56 gh	19.13 b	20.94 a
K3	12.26 e	15.32 b	18.10 ab	17.91 e	17.86 ef	18.01 c

Data in Table (12) showed that, the interactions between nitrogen and potassium application had a significant effect on grain yield (t/ha.), which recorded the best values (3.22 and 3.44t/ha) with apply the nitrogen in three splits N 20-20-20kg, while, apply the potassium in two splits K 12.5-12.5kg, during the two seasons, indicated to apply the nitrogen in different splits will increase the nitrogen response then increase the nitrogen use efficiency plus apply the potassium sulfate will increase the crop growth rate and seed yield/unit. The increase in biomass yield could be attributed to the increase in plant height, number of tillers /m2, number of panicles/hill, panicle weight, seed setting percentage and 1000-grain weight, which increased with application of GA3.

Data in Table (14) showed that, the interactions between potassium and leave foliar application had a significant effect on Seed yield (t/ha.), which recorded the best values (3.49 and 3.51 t/ha) with apply the potassium in one splits K 25kg, which, apply the leave foliar in two splits from IAA in the two seasons, indicated to apply the nitrogen in different splits will increase the nitrogen response then increase the nitrogen use efficiency plus apply the potassium sulfate will increase the crop growth rate and seed yield/unit.

Table (12): The effect of nitrogen and potassium splits with their interactions on seed yield (t/ha.) of female line during 2020 and 2021 seasons.

N	Grain yield (t/ha.)					
	2020			2021		
	K			K		
	K 1	K 2	K 3	K 1	K2	K3
N 1	3.12ac	2.75de	3.09bc	2.36f	3.31ac	3.15d
N 2	2.83de	2.72e	2.86d	3.28c	3.30ac	2.40f
N 3	3.19ab	3.22a	3.05c	3e	3.44a	3.42ab

Data in Table (13) showed that, the interactions between nitrogen and leave foliar application had a significant effect on seed yield (t/ha.) which recorded the best values (3.49-3.51) with apply the nitrogen in three splits N 20-20-20, which, apply the leave foliar in two splits GA3 in the two seasons, indicated to apply the nitrogen in different splits will increase the nitrogen response then increase the nitrogen use efficiency plus apply the growth regulators will increase the crop growth rate and seed yield/unit. These results may be due to the fact that applied GA3 produced higher number of panicles/m2 maximum panicle exertion percentage, the highest panicle length, maximum seed setting percentage, and heavier 1000-grain weight, which consequently gave higher grain yield.

Table (13): The effect of nitrogen splits and leave foliar for hormones with their interactions on seed yield (t/ha.) of female line during 2020 and 2021 seasons.

N	Grain yield (t/ha.)					
	2020			2021		
			GR			GR
	IAA	AA	GA3	IAA	AA	GA3
N 1	3c	2.84d	3.12b	3.08b	2.74d	3.03b
N 2	2.90cd	2.89cd	2.69e	2.91c	3.09b	3.12b
N 3	2.81d	3.15b	3.49a	3.09b	3.12b	3.51a

Table (14): The effect of potassium splits and leave foliar for hormones with their interactions on seed yield (t/ha.) of female line during 2020 and 2021 seasons.

K	Grain yield (t/ha.)					
	2020			2021		
		GR			GR	
	IAA	AA	GA3	IAA	AA	GA3
K1	2.66d	3.33a	3.16b	2.83d	3.46a	3.10c
K2	3.19b	2.71d	2.84c	3.22bc	3.40a	2.71e
K3	2.87c	2.84c	3.30a	3.24b	2.85d	3.10c

Data in Table (15) showed that, the interactions between nitrogen, potassium and leave foliar application had a significant effect on seed yield, which recorded the best values (3.68 and 3.69 t/ha) with apply the nitrogen in three splits N 20-20-20kg, while, apply the potassium in two splits K 12.5-12.5kg and apply GA3 as a growth regulators in the two seasons, indicated to apply the nitrogen in different splits will increase the nitrogen response then increase the nitrogen use efficiency plus apply the potassium sulfate will increase the crop growth rate and seed yield/unit.

Table (15): The effect of nitrogen, potassium splits and leave foliar hormones with their interactions on seed yield t/ha of female line during 2020 and 2021 seasons.

N	K	Grain yield (t/ha.)					
		2020			2021		
			GR			GR	
		IAA	AA	GA3	IAA	AA	GA3
N1	K1	2.65hj	3.20df	3.50ac	2.64ij	2.08m	2.37ik
	K2	3.60ab	2.18mn	2.47hj	3.68a	3.02fg	3.31be
	K3	2.75gi	3.15dg	3.39bd	2.92gh	3.13dg	3.40b
N2	K1	2.37kl	3.66a	2.48ik	3.12dg	3.48ac	3.23df
	K2	3.51ac	2.46ik	2.38kl	3.05eg	3.59ab	3.67a
	K3	2.83gi	2.55gh	3.21df	2.55hi	2.20lm	2.47kl
N3	K1	2.95fh	3.12eg	3.49ac	2.73hi	2.57gh	3.41be
	K2	2.47hj	3.50ac	3.68a	2.94gh	3.57ab	3.69a
	K3	3.02bd	2.82gi	3.31ce	3.59ab	3.23cf	3.43ad

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