Menoufia J. Plant Prod., Vol. 3 February (2018): 85 - 104

IMPACT OF NITROGEN SOURCES AND IRRIGATION WITHHOLDING AT IDENTIFIED GROWTH STAGES OF HYBRID RICE UNDER DRILL SEEDED METHOD

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Received: Dec. 23 , 2017 Accepted: Dec. 30 , 2017

ABSTRACT: *A field experiment was conducted in 2016 and 2017 seasons in a split split-plot design, with four replications, at the Experimental Farm of Rice Research Section located at Sakha Station, Kafr El-Sheikh Governorate. The current study aimed to investigate impact of nitrogen sources and irrigation withholding on hybrid rice. Nitrogen sources viz; urea, ammonium sulphate and ammonium nitrate were arranged in the main plots. Whereas, the time of water stress imposed at three identified growth stages viz; active tillering, panicle initiation and late booting were assigned in the sub plots. However, the duration of water stress viz; 6,8 and 10 days after disappearance of water from the soil surface were allocated in the sub sub-plots under drill seeded rice of Egyptian hybrid rice one. The main results could be summarized as following; the different studied nitrogen sources showed significant effect on rice growth, grain yield and yield attributes as well as protein content. Ammonium sulphate was found to be more beneficial, comparing with other nitrogen sources, since it gave the highest values of growth characteristics, yield attributes and grain yield. However, urea application came in the second rank. On contrary, ammonium nitrate showed less effectiveness. Withholding irrigation at certain growth stage greatly varied in its effect on rice growth, grain yield and yield components. Water withholding at panicle initiation had harmful effect on grain yield and most of the studied traits followed by withholding irrigation at active tillering. Irrigation withholding for 10 days (ADWSS) was more stressfulness while, 6 days withholding was less one. The application of 8 days withholding at late booting stage was considered the best water productivity. The most double interaction had significant effect on all studied traits in both seasons. The interaction results confirmed that ammonium sulphate had high affinity to alleviate the hazardous effect of water withholding at certain rice growth stages. Irrigation withholding at most sensitive rice growth for only 6 days could be applied without significant yield reduction.*

Key word: *Nitrogen source, water stress, growth stages, grain yield, hybrid rice.*

INTRODUCTION

Direct seeded rice (*Oryza sativa* L.) with emphasized on drill seeded rice is considered the future avenue and pertinent for increasing rice productivity and cropping intensity compared with highly production cost of transplanting rice. Among the biotic factors, water and nitrogen is considered the most important interactive phenomena which closely affects rice production under rice condition. Nitrogen is one of the essential macronutrients which is needed for rice growing and maintain grain yield. Ammonium nitrogen form (NH^{+}_{4}) more preferential in rice media rather than nitrate form(NO^{-}_{3}) Wang *et al.,* (1993). Kirk and Kronzucker (2005) gave importance focus for $NO^{-}3$ efficient utilization and absorbing in rice field by nitrification in the rhizosphere. Rice plant could be defined as a plant which prefer ammonium form than nitrate form of nitrogen. Ammonium (NH^{+}_{4}) one of the two inorganic nitrogen sources used by rice plants (NH^{+}_{4} and NO^{-}_{3}) under many circumstances which can improve the capacity of rice plant to tolerate water stress Guo *et al.,* (2007). The factors affected nitrogen use efficiency includes content of nutrients, chemical reactions in soil and nutrient availability to plants in soil. Recovery of N in crop plants is usually less than 50% worldwide Fageria *et al.,* (2010). Where, worldwide, N recovery efficiency for cereal production (rice, wheat, sorghum, millet, barley, corn, oat, and rye) is approximately 33% Jan *et al.,* (2010), and Fageria *et al.,* (2011). Sekhar *et al.,* (2014) found that maximum grain yield was obtained at 168 mg N/kg soil in form of ammonium sulfate and at 152 mg N/kg soil as urea. Maximum grain yield at average N rate (160 mg/kg soil) was 22% higher with the application of ammonium sulfate compared to urea. Rice yield components, N uptake and use efficiency were significantly and positively influenced with the increase of applied ammonium sulfate. Under saline soil conditions, Assefa *et al.,* (2009), Fageria *et al.,* (2010), Chien *et al.,* (2011) and Zayed *et al.,* (2012 and 2017) found that applied ammonium sulfate as nitrogen source significantly surpassed urea application regarding rice growth (LAI, dry matter, chlorophyll content), number of panicles, number of filled grains/panicle, thousand grain weight, panicle weight, grain and straw yields as well as harvest index. Furthermore, applying ammonium sulfate significantly reduced spikelet sterility resulted in heavy panicle and grains as well as high number of filled grains. Around panicle initiation nitrogen concentration reached the ceiling values in rice leaf blades.

Rice leaf blades are considered the active metabolic center which initially received the nitrogen, then assimilation and photosynthesis take place. After heading, the panicle become the active part of rice plant for all physiological activities, translocation of current photosynthesis and the nutrient concentration is relatively higher in panicles than in leaves and stem.

Nutrient accumulation or uptake in different plant parts, as well as in the whole plant, during different phases of growth, clearly indicate higher nitrogen accumulation in stems and leaves during vegetative phase. The nitrogen content in rice leaf is approximately 75% of the total nitrogen presents in plant and is physiologically important in dry matter production through photosynthesis.

El-Wehishy and Abd El-Hafez (1998) found that grain yield and yield components of rice significantly decreased by increasing the irrigation intervals up to 14 days. El-Sharkawy *et al.*, (2006) confirmed that prolonging irrigation interval (12 days) under saline soil is unfavorable for rice growth and it can be observed that flooding every 3 or 6 days should be followed to prevent the soil chemical composition from degenerating and unbalance nutrients. Zayed *et al.*, (2013) found that irrigating every 4 days had favorable effect and improving rice growth and productivity comparing to prolonging irrigation intervals under saline soil and poor water quality.

Hassan *et al.,* (2015) indicated that the 3, 7 and 10 days intervals of irrigation consumed 50%,45% and 36% as much water as, continuous flood. Scarcity of water for irrigation is an alarming issue limiting crop production worldwide

Akram *et al*., (2013) noticed that all the physiological and yield components of rice plant except transpiration rate and number of sterile grains per panicle had a strong and positive correlation with paddy yield. Grain yield and total dry matter production of rice plants stressed at the flowering and panicle initiation stage were significantly lower than those of well watered plants and plants stressed at the vegetative stage Castilo *et al*., (2006) and Ebrahim *et al*., (2009).

Water stress at flowering stage had a greater grain yield reduction than water stress at other times, the reduction of grain yield largely resulted from the reduction in fertile panicle and filling grain yield percentage. Total biomass, harvest index, plant height, filling grains and 1000 grains weight were reduced under water stress

Roshan *et al*., (2013) and Sokoto and Muhammed (2014) as well as Zain *et al*., (2014). Growth characters, grain yield and its components and protein content significantly decreased with water stress, especially at flowering stage compared with other times El-Refaee (2011).

Therefore, the current study aimed to compare three inorganic nitrogen sources and its reflection on rice grain yield of hybrid rice. Also, to find out the most effective irrigation regime on rice grain yield and identify the physiological growth stage which could be mostly affected by water regime.

MATERIALS AND METHODS

A field experiment was conducted during 2016 and 2017 summer seasons at the Experimental Farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate. The study was aimed to find out the proper nitrogen sources for drill seeded rice under irrigation withholding at various rice growth stage along with varying duration of irrigation withholding. The attempts were performed in split split-plot design with four replications. Three nitrogen sources viz; urea (46 % N), ammonium nitrate (33.5 %N) and ammonium sulphate (20.4 %N) were arranged in the main plots. The time of withholding irrigation impost at three identified growth stages viz; active tillering stage, panicle initiation stage and late booting stage were assigned in the sub plots. However, the sub sub-plots were devoted to the three irrigation withholding duration i.e.6, 8 and 10 days after disappearance of water from soil surface (DADWSS). Soil samples were taken from experimental sites to analyses the chemical and physical prosperities and the results were listed in Table (1).

In both seasons, the rice seeds, at the recommended rate of 24 kg ha^{-1}, were sown on 1stMay. Paddy grains of Egyptian hybrid rice one (EHR1) were mechanically drilled, using a cereal grain-drill (the TYE drill, Model No. 104-5200) in rows, spaced at 18 cm and 2 cm below soil surface and plot size was 20 m^2 (4 x 5 m).

The plots were irrigated every five to six days after sowing for one month. The irrigation schedule of drilled seeded rice was used as recommended and followed up to tested irrigation withholding application parallel with each growth stage as abovementioned. Nitrogen in the above varying forms was applied at the rate of 220 kg ha^{-1}into four equal splits top dressing with the first water head and one fourth at each growth stage after irrigation water regime terminal. Phosphorus (35.5 kg P_2O_5/ha), potassium (57 kg K_2O/ha) and zinc (Zn So_4, 28 % Zn) as well as all other cultural practices were followed as recommended. To avoid lateral movement and more water control, each main plot was separated by 2 meter wide ditches. Water pump provided with a calibrated water meter was used for water measurements. Water productivity (WP) was calculated as weight of grains per unit of water used (kg grain/m^3 water).

Table (1): Some chemical properties of the experimental site during 2016 and 2017 seasons.

Characters	2016	2017
Texture	Clayey	Clayey
pH(1:2.5 soil extract)	8.00	8.20
EC dSm^{-1} (soil paste)	2.30	2.55
OM %	1.55	1.49%
N %	0.050	0.049
P (available) ppm	1580	14.00
K (available) ppm	485.00	500.00
Zn (available) ppm	1.00	1.08

At heading stage, number of days from sowing to 50 % heading was recorded in each sub sub-plot. Plant samples were collected from an area of 0.135 m^2 (0.75 m long of row) from each plot to estimate dry matter production and leaf area index. Chlorophyll content (SPAD value) was estimated by chlorophyll meter (Model Li3000L). N-flag leaf content was estimated according to Hafez and Mikkelson (1981) and canopy index was estimated according to Jiang *et al*., (1993).

At harvest, average plant height was estimated by measuring the height from the soil surface up to the longest panicle and total number of panicles, of an area of 0.135 m^2, were counted and, then, conformed to numbers m^{-2}. Ten main panicles from each plot were randomly packed to determine panicle length, total number of grains $panicle^{-1}$, number of chaffy grains $panicle^{-1}$, sterility percentage, number of primary branches $panicle^{-1}$, panicle weight and 1000-grain weight. An area of $9m^2$ (2 x 4.5 m) from central rows in each plot were harvested, dried, threshed, then grain and straw yields were determined and adjusted to 14 % moisture content and then, converted into t ha^{-1}. Improved Kjeldahl method of A.O.A.C. (1970) was used to determine the N content, then, multiplied by the factor 5.95 to estimate the crude protein in rough grains.

All data collected were subjected to standard statistical analysis following the proceeding described by Gomez and Gomez (1984) using the computer program (MSTAT). The treatment means were compared using Duncan's multiple range test Duncan (1955).

RESULTS AND DISCUSSIONS

A- Growth characteristics:

Data in Table 2, showed that growth characters of EHR1 rice cultivar were significantly affected by nitrogen source, different time and duration of water stress in both studied seasons.. Regarding nitrogen sources ammonium sulphate gave the highest values of dry matter production, chlorophyll and N contents in flag leaf, leaf area index (LAI) , canopy index (CI) and plant height. The nitrogen in the form of ammonium nitrate showed inferior behavior and gave the lowest values of measured growth characteristics in both seasons. While, the longest period from sowing to heading were obtained when rice was fertilized by urea which occupied middle rank compared to other nitrogen source for rice growth traits. The superiority of ammonium sulphate mainly attributed to its acidity form reflected on reducing alkalinity of soil resulted in more nutrient availability. Furthermore, ammonium sulphate is slow nitrogen release that enables plant to find its nitrogen need during its growth duration. Ammonium sulphate contains sulfur nutrient which increase the metabolism, photosynthesis and protein formation. However, nitrogen losses occurred in the form of ammonium nitrate due to NO_3^- reduced its nitrogen use efficiency and rice plant growth. Similar results had been reported by Assefa *et al*., (2009), Fageria *et al.,* (2010), Chien *et al*., (2011) and Zayed *et al.,* (2012 and 2017).

Regarding time of water withholding the highest values of dry matter production, chlorophyll content, N flag leaf content, LAI and canopy index were produced by irrigation withholding occurred at late booting except, plant height which recorded the lowest values Table 2. Such results agreed with those obtained by El-Refaee (2011). The lowest values of plant height indicated that character was the most sensitive to water stress. Seriously, the water withholding at panicle initiation was more affected on most of rice growth, since it gave the lowest values of studied growth in both seasons. At panicle initiation, plants reached its growth peak and any water stress is going to inhibit growth parameters.

Table (2): Days to 50% heading, dry matter production, chlorophyll content, N-content, leaf area index, canopy index and plant height as affected by nitrogen sources, time and duration of water stress at identified growth stages of EHR1 under drill seeded rice in 2016 and 2017 seasons.

Treatment	Days to 50% heading		Dry matter production (g/m^2)		Chlorophyll content in flag leaf (SPAD)		N-content in flag leaf		Leaf area index		Canopy index		Plant height at harvest (cm)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Nitrogen source (N):														
Urea	108.0a	107.0a	2175.5b	2132.6b	41.24b	40.24b	2.11b	2.07b	8.78b	8.53b	18.59b	17.76b	91.0b	91.8a
A. Nitrate	106.4c	105.7c	1810.4c	1755.9c	38.13c	39.94b	1.89c	1.83c	6.64c	6.49c	12.59c	12.01c	89.4c	89.2b
A. Sulphate	107.2b	106.2b	2377.6a	2280.7a	42.65a	41.68a	2.28a	2.20a	8.91a	8.72a	20.47a	19.20a	92.2a	91.9a
F. test	**	**	**	**	**	**	**	**	**	**	**	**	*	**
Time of water stress (T):														
Active tillering	106.8c	105.9c	2166.6b	2098.5b	40.59b	40.94a	2.07b	2.01b	8.06b	7.81c	16.84b	15.88b	92.3a	92.0
Panicle initiation	107.2b	106.3b	1957.2c	1906.7c	40.31b	40.16b	2.05b	1.99c	8.04b	7.89b	16.64b	16.02b	90.4b	90.9
Late booting	107.6a	106.7a	2239.6a	2164.1a	41.13a	40.76a	2.17a	2.09a	8.23a	8.05a	18.14a	17.08a	89.8c	90.1
F. test	**	**	**	**	**	**	**	**	**	**	**	**	*	NS
Duration of water stress (D):														
6 days	106.2c	105.2c	2318.5a	2236.7a	43.27a	41.57a	2.33a	2.24a	8.69a	8.46a	20.13a	19.08a	93.2a	93.0a
8 days	107.2b	106.3b	2157.4b	2098.1b	40.79b	40.71b	2.10b	2.05b	8.30b	8.07b	17.65b	16.73b	91.2b	91.7b
10 days	108.2a	107.4a	1887.6c	1834.4c	37.97c	39.58c	1.85c	1.81c	7.34c	7.21c	13.84c	13.17c	88.1c	88.3c
F. test	**	**	**	**	**	**	**	**	**	**	**	**	**	**
Interaction:														
NxT	**	**	**	**	**	**	*	*	**	**	**	**	NS	NS
NxD	**	**	**	**	**	NS	**	**	**	**	**	**	NS	NS
TxD	**	**	**	**	**	**	**	**	**	**	**	**	NS	NS
NxTxD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*, ** and NS indicate P < 0.05, P < 0.01 and not significant, respectively. Means of each factor designated by the same latter are not significantly different at 5% level using DMRT.

Regarding the duration of water stress, the exposed plants to 6 days water withholding after disappearance of water from the soil surface (ADWSS) produced the highest dry matter production, chlorophyll and N flag leaf content, LAI, canopy index and plant height in both seasons. The water holding for 10 days gave the lowest values of estimated growth parameters. Castilo *et al., (*2006), Ebrahim *et al.,* (2009), Roshan *et al.,* (2013), Sokoto and Muhammed (2014) and Zain *et al.,* (2014) came to similar results.

The interaction among N sources, time and duration of irrigation withholding had significant effect on days to heading, dry matter, chlorophyll and N- flag leaf contents, leaf area index and canopy index in both seasons (Tables 2, 3 and 4). The combination of ammonium sulphate and water withholding at late boating was the best regarding the above-mentioned traits. Water withholding at panicle initiation was more restricted to growth parameters along with 10 days period in both seasons. At the same time, water withholding at late boating stage for 10 days (ADWSS) prolonged the period from sowing to heading. Water withholding at active tillering and panicle initiation shortened the period from sowing to heading. The growth characteristics performed better under the combination of withholding irrigation at panicle initiation along with 6 days water withholding at growth duration along with ammonium sulphate showed better growth. The interaction effects confirmed that applying ammonium sulphate can alleviates the hazardous effect of water deficit. Out of the forms of N, in paddy field, ammonium (NH^{+}_{4}) form is more preferred rather than the nitrate (NO^{-}_{3}) form and it can be taken up directly through roots, even though uptake can occur in biphasic manner.

In rice, N is primarily available in the form of nitrate (NO^{-}_{3}) and ammonium (NH^{+}_{4}). The NO^{-}_{3} is a most predominant form in agricultural soils Crawford (1995) taken up by active transport through the roots, distributed through the xylem and assimilated by the sequential action of the enzymes nitrate reductase (NR) and nitrite reductase (NiR) followed by ammonium assimilation, amino acid biosynthesis, and protein synthesis. The nitrate produced by nitrification has been shown to be taken up with the diffusion of oxygen through the roots Davatgar *et al,.* (2009).

B- Grain yield and its attributes:

1- Number of panicles/m^2, filled grains/panicle, number of chaffy grains/panicle, sterility percentage, panicle length and primary branches/ panicle

Data documented in Tables 5 clarified that some of grain yield attributes were significantly affected by nitrogen source, different times of water withholding during 2016 and 2017 seasons.

Nitrogen sources had a significant impact on all grain yield attributes in both seasons, except number of chaffy grains/panicle in the first season and primary branches/panicle in the second season. The maximum values of number of panicle/m^2 and filled grains/ panicle were obtained by ammonium sulphate without significant difference with urea compared to ammonium nitrate. Ammonium sulphate surpassed the rest two nitrogen sources and gave the highest value of panicle length and number of chaffy grains/ panicle, while the lowest percentage of sterility was produced by urea which gave the highest value of primary branches/ panicle. The lowest values of mentioned traits were produced when rice plants were fertilized by ammonium nitrate. The ammonium sulphate had high affinity to improve both soil properties and plant growth reflected in grain yield attributes. Also, using ammonium sulphate as nitrogen source ensured high nitrogen content in flag leaf resulted in high current photosynthesis in such organ leading to improving panicle characteristics such as filling and weight and ultimately giving higher grain yield. A similar result has been detected by Assefa *et al.,*

Table (3): Days to 50% heading, dry matter production and chlorophyll content as affected by the interaction among nitrogen sources, time and duration of water stress at identified growth stages of EHR1 under drill seeded rice in 2016 and 2017 seasons.

Character	Treatment	Nitrogen source					
		2016			2017		
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
Days to 50% heading	Time of water stress						
	Active tillering	107.0d	106.0f	107.3bc	106.0e	105.2f	106.4d
	Panicle initiation	108.0b	107.0d	106.7de	106.9b	106.3d	105.5f
	Late booting	108.9a	106.3de	107.7b	108.0a	105.4f	106.7bc
	Duration of water stress						
	6DADWSS	107.0de	105.eg	106.0f	105.9f	104.8h	105.0h
	8 DADWSS	108.0bc	106.3f	107.3d	107.0c	104.8h	105.0h
	10 DADWSS	108.9a	107.3d	108.3b	108.1a	106.7d	107.4b
	Duration of water stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	106.0d	106.3d	106.3d	105.1e	105.2e	105.3de
	8 DADWSS	106.3d	107.7bc	107.7bc	105.6d	106.6c	106.7bc
	10 DADWSS	108.0b	107.7bc	108.9a	107.0b	107.0b	108.1a
Dry matter production (g/m^2)	Time of water stress	Nitrogen source					
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
	Active tillering	2167.7c	1873.3e	2458.9a	2126.7c	1822.2e	2346.7a
	Panicle initiation	2022.2d	1667.8f	2181.7c	1997.8d	1624.4f	2097.8c
	Late booting	2336.7b	1890.0e	2492.2a	2273.3b	1821.1e	2397.8a
	Duration of water Stress						
	6DADWSS	2308.9c	2070.0f	2576.7a	2248.9c	2000.0f	2461.1a
	8 DADWSS	2219.9d	1842.2h	2410.0b	2195.6d	1786.7g	2312.2b
	10 DADWSS	1997.8g	1518.9i	2146.1e	1953.3f	1481.1h	2068.9e
	Duration of water Stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	2332.2b	2204.4c	2418.9a	2267.8b	2116.7c	2325.6a
	8 DADWSS	2147.7d	2022.2e	2302.2b	2087.8c	1990.0d	2216.7b
	10 DADWSS	2020.0e	1645.0f	1997.8e	1940.0d	1613.3e	1950.0d
Chlorophyll content (SPAD)	Time of water stress	Nitrogen source					
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
	Active tillering	40.68c	37.92d	43.17a	40.61cd	40.09de	42.11a
	Panicle initiation	41.43b	38.22d	41.29b	39.09f	39.78ef	41.62ab
	Late booting	41.62b	38.26d	43.50a	40.02bc	39.94de	41.31bc
	Duration of water Stress	Nitrogen source (2016)					
		Urea		A. nitrate		A. sulphate	
	6DADWSS	43.70		41.42e		44.68a	
	8 DADWSS	41.44d		38.07f		42.86c	
	10 DADWSS	38.59f		34.91g		40.42f	
	Duration of water Stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	42.72b	43.17b	43.91a	41.11bc	41.37b	42.22a
	8 DADWSS	43.17b	40.14d	41.50c	41.00bc	40.16d	40.99bc
	10 DADWSS	37.63e	37.63e	37.97e	40.70c	38.97e	39.07e

Means of each factor designated by the same latter are not significantly different at 5% level using DMRT.
DADWSS = days after disappearance of water from soil surface.

Table (4): N-content in flag leaf, Leaf area index and Canopy index as affected by the interaction among nitrogen sources, time and duration of water stress at identified growth stages of EHR1 under drill seeded rice at flowering in 2016 and 2017 seasons.

Character	Treatment	Nitrogen source					
		2016			2017		
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
N-content in flag leaf	Time of water stress						
	Active tillering	2.08c	1.86e	2.27ab	2.06d	1.82f	2.17b
	Panicle initiation	2.07c	1.84e	2.24ab	2.07cd	1.76g	2.14b
	Late booting	2.19b	1.97d	2.33a	2.09c	1.91e	2.28a
	Duration of water Stress						
	6DADWSS	2.38a	2.17c	2.44a	2.33a	2.06c	2.33a
	8 DADWSS	2.20bc	1.83d	2.28b	2.15b	1.80d	2.19b
	10 DADWSS	1.76d	1.67e	2.14c	1.73d	1.62f	2.07c
		Time of water stress					
	Duration of water Stress	Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	2.22c	2.34b	2.43a	2.19b	2.21b	2.32a
	8 DADWSS	2.09d	2.00e	2.21c	2.03d	1.98e	2.14c
	10 DADWSS	1.90f	1.81f	1.86f	1.83f	1.78g	1.82f
Leaf area index		Nitrogen source					
	Time of water stress	Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
	Active tillering	8.34e	6.89f	8.93c	8.08e	6.69f	8.66c
	Panicle initiation	8.94c	6.61g	8.57d	8.76bc	6.44g	8.46d
	Late booting	9.04b	6.42h	9.23a	8.77b	6.32h	9.06a
	Duration of water Stress						
	6DADWSS	9.19b	7.38e	9.50a	8.93b	7.17f	9.28a
	8 DADWSS	8.88c	6.96f	9.07b	8.53c	6.78g	8.89b
	10 DADWSS	8.27d	5.59g	8.17d	8.13d	5.50h	8.00e
		Time of water stress					
	Duration of water Stress	Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	8.44b	8.84a	8.78a	8.24c	8.61a	8.53b
	8 DADWSS	8.14c	8.37b	8.39b	7.87e	8.18d	8.16d
	10 DADWSS	7.58d	6.91e	7.53d	7.31d	6.87h	7.46f
Canopy index		Nitrogen source					
	Time of water stress	Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
	Active tillering	17.21f	12.85g	20.44b	16.67d	12.20e	18.77b
	Panicle initiation	18.63e	11.91h	19.37d	18.22c	11.63f	18.20c
	Late booting	19.94c	12.91g	21.58a	18.41c	12.20e	20.64a
	Duration of water Stress						
	6DADWSS	21.68b	15.55f	23.15.a	20.83b	14.70f	21.70a
	8 DADWSS	18.56d	12.73h	20.66c	18.35d	12.38h	19.46c
	10 DADWSS	14.54g	9.39i	17.59e	14.11g	8.96i	16.45c
		Time of water stress					
	Duration of water Stress	Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	18.75c	20.22b	21.41a	18.14c	19.19b	19.91a
	8 DADWSS	17.21d	17.00d	18.74c	16.07f	16.54e	17.58c
	10 DADWSS	14.54e	12.69f	14.28e	13.43g	12.32h	13.76g

Means of each factor designated by the same latter are not significantly different at 5% level using DMRT.
DADWSS = days after disappearance of water from soil surface.

Table (5): Number of panicle/m^2, filled grains/panicle, number of chaffy grains/panicle, sterility (%), panicle length and primary branches/panicle as affected by nitrogen sources, time and duration of water stress at identified growth stages of EHR1 under drill seeded rice in 2016 and 2017 seasons.

Treatment	No. of panicles/ m^2		Filled grains / panicle		No. of chaffy grains/panicle		Sterility (%)		Panicle length (cm)		Primary branches/ panicle	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Nitrogen source (N):												
Urea	621.0a	614.1a	138.6a	138.0a	16.8c	17.2	10.8b	11.2b	20.8b	21.0b	9.5	9.9a
A. Nitrate	566.4b	562.4b	132.3b	131.4b	17.8b	17.0	12.0a	11.7a	19.6c	20.7b	9.3	9.4c
A .Sulphate	629.6a	620.0a	138.8a	138.5a	18.8a	16.9	12.0a	11.0b	21.8a	21.7a	9.5	9.6b
F. test	**	**	**	**	**	NS	**	**	*	**	NS	*
Time of water stress (T):												
Active tillering	605.7b	601.1a	135.8b	136.0b	17.4b	16.6b	11.4b	11.0b	21.0b	21.2b	9.4b	9.4c
Panicle initiation	594.0b	588.7b	133.5c	132.6c	18.7a	17.9a	12.4a	12.2a	18.6c	20.8c	9.7a	9.9a
Late booting	617.3a	606.7a	140.3a	139.3a	17.2b	16.7a	11.0c	11.0b	22.7a	21.5a	9.3b	9.7b
F. test	**	**	**	**	**	**	**	**	*	**	*	*
Duration of water stress (D):												
6 days	636.9a	628.6a	145.0a	144.4a	13.3c	12.5c	8.4c	8.0c	21.8a	21.9a	9.7a	9.9a
8 days	608.1b	601.8b	137.4b	137.3b	17.7b	17.10b	11.3b	11.1b	20.8b	21.2b	9.5b	9.7a
10 days	572.0c	566.1c	127.2c	126.1c	22.4a	21.6a	15.0a	14.8a	19.5c	20.3c	9.0c	9.4b
F. test	**	**	**	**	**	**	**	**	**	**	*	*
Interaction:												
NxT	**	**	**	**	**	**	**	**	**	**	NS	NS
NxD	**	**	**	**	**	**	**	**	NS	NS	NS	NS
TxD	**	**	**	**	**	**	**	**	**	**	**	**
NxTxD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*, ** and NS indicate P < 0.05, P < 0.01 and not significant, respectively. Means of each factor designated by the same latter are not significantly different at 5% level usingDMRT.

(2009), Fageria *et al.,* (2010), Chien *et al.,* (2011) and Zayed *et al.,* (2012 and 2017). Time of irrigation withholding significantly affected grain yield attributes in both seasons Table 5. The highest values of number of panicle/m^2, filled grains/panicle and panicle length were produced by water stress at late booting stage. However, the greatest values of chaffy grains/panicle, sterility percentage, primary branches/ panicle were noticed by water stress at panicle initiation. The irrigation withholding at panicle initiation was more restricted on above grain yield attributes in both seasons.

Duration of water stress, at identified growth stages, significantly affected the above mention traits in both seasons Table 5. The highest values of chaffy grains/ panicle and sterility percentage were produced by irrigation withholding for 10 days (ADWSS). The highest value of number of panicle/m^2, filled grains/ panicle, panicle length and primary branches/panicle were produced by the lowest duration of irrigation withholding (6 days) followed by 8 days (ADWSS) in both seasons. However, the long duration of irrigation withholding (10 days)was more sever and produced the lowest values of panicle number/m^2, filled grain/panicle, panicle length and primary branch/ panicle. The water stress reduced water cell, nutrient uptake, cell division, cell elongation, metabolism and photosynthesis as well as assimilation resulted in low panicle formation, low filled grains, low 1000- grain weight and low panicle weight. Castilo *et al.,* (2006) and Ebrahim *et al.,* (2009) Roshan *et al.*, (2013), Sokoto and Muhammed (2014) as well as Zain *et al.,* (2014) indicated similar results. The interaction between nitrogen sources and duration of water stress, at identified growth stages, significantly affected number of panicle/m^2 Table 6. The combination between irrigation withholding at active tillering with ammonium sulphate gave the highest number of panicle/m^{2}in the first season. While, withholding irrigation at late booting with urea or ammonium sulphate gave the highest number of panicle/m^{2}in the second season.

Ammonium sulphate and urea along with irrigation withholding at late booting gave the highest value of filled grains/panicle in both seasons. The highest value of chaffy grains/panicle was obtained by ammonium sulphate under water stress during panicle initiation in the first season. While, ammonium nitrate and urea along with withholding irrigation at panicle imitation gave the highest values of chaffy grains/panicle in the second season. The lowest value of sterility was noticed by water stress at late booting and urea application. While, the combination between water stress during panicle initiation and ammonium nitrate gave the highest sterility percentage in both seasons. The longest panicle was produced by the combination of urea application and withholding irrigation at active tillering without significant difference with combination of ammonium nitrate and irrigation withholding at panicle initiation and also, ammonium sulphate along with irrigation withholding at late booting in both seasons.

The interaction between nitrogen sources and duration of irrigation withholding at certain growth stages significantly affected number of panicle/m^2, filled grains/ panicle, sterility percentage, number of chaffy grains/panicle in both seasons Tables 6 and 7. The combination between withholding irrigation for 6 days (ADWSS) and ammonium sulphate or ammonium nitrate gave the highest value of number of panicle/m$^{2.}$ The combination between the withholding irrigation of 6 days (ADWSS) and ammonium sulphate gave the highest value of filled grains/panicle in both seasons. The highest value of number of chaffy grains/panicle was obtained by the combination between the duration of water stress for 10 days (ADWSS) and ammonium sulphate. Otherwise, the highest sterility percentage was noticed by the duration of water stress for 10 days (ADWSS) and

Table (6): Number of panicles, filled grains/panicle and number of chaffy grains/panicle as affected by the interaction among nitrogen sources, time and duration of water stress at identified growth stages of EHR1 under drill seeded rice in 2016 and 2017 seasons.

Character	Treatment	Nitrogen source (N)					
		2016			2017		
		Urea	A. nitrate	A.sulphate	Urea	A. nitrate	A. sulphate
No. of panicles/ m^2	Time of water stress						
	Active tillering	628.8b	634.3b	647.6a	613.8bc	569.2e	620.2b
	Panicle initiation	605.4d	597.0e	621.8c	601.4d	553.1f	611.7c
	Late booting	582.8f	550.6g	582.6f	627.0a	565.0e	628.1a
	Duration of water Stress						
	6DADWSS	646.7a	617.7c	646.3a	640.3a	608.7c	636.8a
	8 DADWSS	627.3b	563.0f	633.9b	621.9b	561.1e	622.3b
	10 DADWSS	588.9e	518.4g	608.6d	580.d	517.6f	600.9c
	Duration of water stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	628.8c	634.3b	647.6a	624.6a	629.4a	631.8a
	8 DADWSS	605.4d	597.0d	621.8c	600.0c	592.2c	613.1b
	10 DADWSS	582.8e	550.6f	582.6e	578.7d	544.6e	575.2d
Filled grains /panicle	Time of water stress	Nitrogen source (N)					
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
	Active tillering	134.6c	133.9c	138.9b	133.7e	135.2cd	139.1b
	Panicle initiation	137.9b	130.4c	132.2c	136.4c	128.8g	132.5ef
	Late booting	143.2a	132.2c	145.3a	143.8a	130.1fg	143.9a
	Duration of water stress						
	6DADWSS	145.5b	141.5c	148.1a	144.3b	141.6c	147.4a
	8 DADWSS	139.1c	134.2d	139.0c	139.3cd	133.7e	138.8d
	10 DADWSS	131.2e	121.1f	129.3e	130.2f	118.8g	129.4f
	Duration of water stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	139.5bc	141.7b	154.0a	138.3c	141.7b	153.3a
	8 DADWSS	136.9cd	134.6d	140.7b	136.2cd	134.7de	140.9b
	10 DADWSS	131.0e	124.3f	126.3f	133.6e	121.3f	123.5f
No. of chaffy grains/panicle	Time of water stress	Nitrogen source (N)					
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
	Active tillering	17.1c	17.0c	18.3b	16.7c	16.4c	16.5c
	Panicle initiation	17.7c	18.9b	19.6a	18.0a	18.2a	17.5ab
	Late booting	15.5d	17.5c	18.5b	16.8c	16.4c	16.7c
	Duration of water stress						
	6DADWSS	12.5f	13.8e	13.7e	12.6d	13.0d	11.8e
	8 DADWSS	16.4d	18.0c	18.6c	17.0c	17.2c	17.2c
	10 DADWSS	21.5b	21.6b	24.1a	22.0d	20.9b	21.8a
	Duration of water stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	11.3c	11.4bc	9.9d	11.3d	11.6bc	10.8de
	8 DADWSS	11.4bc	12.8a	11.7b	11.1de	12.6a	11.5bcd
	10 DADWSS	11.6bc	13.0a	11.4bc	10.7e	11.8b	10.7e

Means of each factor designated by the same latter are not significantly different at 5% level using DMRT.
DADWSS = days after disappearance of water from the soil surface.

Table (7): Sterility (%), panicle length and Primary branches/ panicle as affected by the interaction among nitrogen sources, time and duration of water stress at identified growth stages of EHR1 under drill seeded rice in 2016 and 2017 seasons.

Character	Treatment	Nitrogen source (N)					
		2016			2017		
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
Sterility (%)	<u>Time of water stress</u>						
	Active tillering	11.3c	11.4bc	11.6bc	11.3d	11.6bc	10.8de
	Panicle initiation	11.4bc	12.8a	13.0a	11.1d	12.6a	11.5bcd
	Late booting	9.9d	11.7b	11.4bc	10.7de	11.8b	10.7e
	<u>Duration of water stress</u>						
	6DADWSS	7.9f	8.9e	8.5e	8.1de	8.4d	7.5e
	8 DADWSS	10.5d	11.8c	11.8c	11.0c	11.4c	11.0c
	10 DADWSS	14.1b	15.2a	15.7a	14.5b	15.4a	14.6b
	Duration of water stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	9.5g	8.6h	7.3i	8.8e	8.3e	6.9f
	8 DADWSS	11.3e	12.3d	10.5f	11.0d	11.9c	10.5d
	10 DADWSS	13.5c	16.2a	15.3b	13.1b	15.9a	15.5a
Panicle length (cm)	Time of water stress	Nitrogen source (N)					
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
	Active tillering	21.2a	20.5b	21.1a	21.5ab	20.0d	21.9a
	Panicle initiation	20.5ab	21.1a	20.1b	20.6c	20.6cd	21.1bc
	Late booting	207ab	20.2b	21.2a	21.0bc	21.5ab	22.0a
	Duration of water stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	21.0a	21.8a	21.9a	22.0bc	22.3a	22.0a
	8 DADWSS	21.0ab	20.8ab	20.4b	21.1cd	20.9d	21.6b
	10 DADWSS	20.8ab	19.2c	19.8bc	21.1cd	19.0e	20.8d
Primary branches/ panicle	Duration of water stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	9.4bc	10.3a	9.3bc	9.5c	9.5c	9.4cd
	8 DADWSS	9.5bc	9.7b	9.3bc	10.6a	9.9b	9.2d
	10 DADWSS	9.4bc	9.1c	9.3bc	9.6c	9.6c	9.6c

Means of each factor designated by the same latter are not significantly different at 5% level using DMRT.
DADWSS = Days after disappearance of water from the soil surface.

ammonium nitrate. On the other hand, the lowest value of sterility percentage was obtained by the combination between irrigation withholding for 6 days (ADWSS) and ammonium sulphate.

The interaction between time and duration of water stresses at varying growth stages significantly affected number of panicle/m^2, filled grains/ panicle, sterility percentage, panicle length, number of chaffy grains/ panicle and primary branches/ panicle in the two seasons of study Tables 6 and 7. The combination of irrigation withholding for 6 days (ADWSS) at late booting (in both seasons) and at active tillering or panicle initiation (in the second season) gave the highest value of number of panicle/m^2. As for number of chaffy grains/ panicle the maximum value was produced by withholding irrigation for 10 days at panicle initiation in the first season and for 8 days at panicle initiation in the second season. The highest value of primary branches/panicle was obtained by the withholding irrigation for 6 days at panicle initiation in the first season and for 8 days at active tillering in the second season. The interaction effect clearly confirmed that the irrigation withholding at panicle initiation was more seriously than happened at late booting stage. Irrigation withholding for 10 days at panicle initiation gave the highest value of sterility percentage in both seasons. The highest value of panicle length was noticed by the combination between the duration of water stress for 6 days at panicle initiation and late booting in both seasons.

2- Panicle weight, 1000-grain weight, grain yield, straw yield, harvest index and protein content

Nitrogen sources had a significant impact on panicle weight, 1000-grain weight, grain yield, straw yield, harvest index and protein content (Table 8). The heaviest panicle, 1000-grain and the maximum value of grain yield were obtained by application of ammonium sulphate followed by urea while, ammonium nitrate came in the last order in both seasons. Urea gave the highest value of straw yield, harvest index and protein content without significant differences with ammonium nitrate for straw yield in both seasons and for harvest index and protein content in first season. Authors such as Fageria *et al.,* (2010), Zayed (2012) and Sekhar *et al.,* (2014) as well as Zayed *et al.,* (2017) reported similar results. The highest values of panicle weight, 1000-grain weight, grain yield were produced by time of water stress at late booting stage in both seasons. Otherwise, the maximum values of straw yield, harvest index and protein content were noticed by withholding irrigation at mid tillering. On the other hand, withholding at late boating exerted the minimum values of straw yield, harvest index and protein Table 8. Withholding at panicle initiation was more restricted on grain yield and its components except, protein content, as formerly mentioned.

Water withholding at panicle initiation affected main grain yield components and panicle characteristics lead to low grain yield comparing to water withholding at other growth stages.

The maximum values of panicle weight, 1000-grain weight, grain yield, straw yield and harvest index as well as protein content were produced by irrigation withholding for 6 days in both seasons Table 8. Prolonging water withholding up to 10 days (ADWSS) induced sharp decrease in all grain yield attributed resulted in remarkable reduction in grain yield in both seasons. Several authors such as Fageria *et al,.* (2010), Zayed (2012) and Sekhar *et al.,* (2014) as well as Zayed *et al.,* (2017) clamed similar findings.

The interaction between nitrogen sources and duration of water stress at identified growth stages significantly affected on panicle weight, 1000-grain weight, grain yield, and protein content in both seasons (Tables 9 and 10). The heaviest panicle was produced by ammonium sulphate under irrigation withholding at active tillering, in the first season, and ammonium sulphate under irrigation withholding at late booting stage, in the second season. In addition, the highest value of 1000-grain weight was produced by ammonium sulphate without significant difference with ammonium nitrate under irrigation withholding at late booting. Ammonium sulphate and irrigation withholding at active tillering(in the first season)as well as urea with irrigation withholding at late booting (in the second

Table (8): Panicle weight, 1000-grain weigh, grain yield, straw yield, harvest index and protein content as affected by nitrogen sources, time and duration of water stress at identified growth stages of EHR1 under drill seeded rice in 2016 and 2017 seasons.

Treatment	Panicle weight (g)		1000-grain weight (g)		Grain yield (t/ha)		Straw yield (t/ha)		Harvest index		Protein content	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Nitrogen source (N):												
Urea	3.29c	3.61c	23.0b	22.8c	11.65b	11.38b	17.45a	17.39a	40.83a	40.51a	7.66a	7.77a
A. Nitrate	3.52b	3.79b	24.2a	23.2b	10.54c	10.45c	17.09a	17.24a	40.50a	39.41b	7.58a	7.44b
A .Sulphate	3.71a	4.04a	23.8a	23.9a	12.06a	11.89a	16.02b	16.04b	39.64b	39.39b	7.28b	7.41b
F. test	*	*	**	**	**	**	**	**	**	*	**	**
Time of water stress (T):												
Active tillering	3.57b	3.79b	23.4b	23.3b	11.45b	11.25b	17.10a	17.00a	41.66a	40.63a	7.62a	7.66a
Panicle initiation	3.48b	3.72b	22.8a	22.9c	10.94c	10.79c	16.89a	16.88b	40.37b	39.94b	7.54a	7.53b
Late booting	3.87a	3.96a	24.8a	23.8a	11.86a	11.68a	16.57b	16.80b	38.94c	38.74c	7.36b	7.42c
F. test	*	*	**	**	**	**	**	**	**	**	**	**
Duration of water stress (D):												
6 days	3.70a	3.96a	24.2a	24.3a	12.06a	11.78a	17.20a	17.17a	41.22a	40.33a	8.16a	8.26a
8 days	3.53b	3.86a	23.7b	23.6b	11.49b	11.36b	17.19a	17.17a	40.01b	39.73b	7.54b	7.47b
10 days	3.30c	3.63b	23.2c	22.0c	10.70c	10.59c	16.18b	16.34b	39.73b	39.26b	6.81c	6.89c
F. test	*	*	**	**	**	**	**	**	**	**	**	**
Interaction:												
NxT	**	**	**	**	**	**	NS	NS	NS	NS	**	**
NxD	NS	NS	**	**	**	**	*	NS	**	**	NS	NS
TxD	NS	NS	*	*	**	**	NS	*	*	*	**	**
NxTxD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*, ** and NS indicate P < 0.05, P < 0.01 and not significant, respectively. Means of each factor designated by the same latter are not significantly different at 5% level using DMRT.

Table (9): Panicle weight, 1000-grain weight and grain yield as affected by the interaction among nitrogen sources, time and duration of water stress at identified growth stages of EHR1 under drill seeded rice in 2016 and 2017 seasons.

Character	Treatment	Nitrogen source (N)					
		2016			2017		
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
Panicle weight (g)	Time of water stress						
	Active tillering	3.29ef	3.63bc	3.78a	3.60de	3.77cd	4.01b
	Panicle initiation	3.33ef	3.51cd	3.61bc	3.58e	3.77cd	3.81c
	Late booting	3.25f	3.42de	3.73ab	3.67cde	3.81c	4.31a
1000-grain weight (g)	Time of water stress	Nitrogen source (N)					
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
	Active tillering	23.4bc	24.2ab	22.6c	23.0cde	23.1cd	23.9b
	Panicle initiation	23.1c	24.1ab	24.2ab	22.6ef	22.6f	23.4c
	Late booting	22.6c	24.3a	24.6a	22.7def	24.0ab	24.4a
	Duration of water stress						
	6DADWSS	23.8b	24.5a	24.2ab	23.4e	24.5b	24.9a
	8 DADWSS	22.8d	24.2ab	23.9b	23.0f	23.7d	24.1c
	10 DADWSS	22.5d	23.8b	23.3c	21.9h	21.4i	22.7g
	Duration of water stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	23.4cd	24.3b	24.8a	23.7cd	24.1b	24.9a
	8 DADWSS	23.6cd	23.8c	23.6c	23.4d	23.5d	24.0bc
	10 DADWSS	23.3cd	23.2cd	23.0d	22.8e	21.0g	22.2f
Grain yield (t/ha)	Time of water stress	Nitrogen source (N)					
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
	Active tillering	11.31bc	10.79d	12.26a	10.92d	10.73e	12.09b
	Panicle initiation	11.07c	10.23e	11.50b	10.90d	10.12g	11.33c
	Late booting	12.57a	10.61d	12.41a	12.32a	10.49f	12.24a
	Duration of water stress						
	6DADWSS	12.12b	11.21d	12.87a	11.74c	11.01e	12.58a
	8 DADWSS	11.72c	10.66e	12.10b	11.39d	10.65f	12.02b
	10 DADWSS	11.11d	9.77f	11.21d	11.01e	9.69g	11.06e
	Duration of water stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	12.00b	11.62c	12.57a	11.68c	11.44d	12.20a
	8 DADWSS	11.48c	10.97d	12.02b	11.33e	10.77fg	11.97b
	10 DADWSS	10.88d	10.22e	10.99d	10.73g	10.14h	10.88f

Means of each factor designated by the same latter are not significantly different at 5% level using DMRT.
DADWSS = Days after disappearance of water from the soil surface.

Table (10): Straw yield, harvest index and protein content as affected by the interaction among nitrogen sources, time and duration of water stress at identified growth stages of EHR1 under drill seeded rice in 2016 and 2017 seasons.

Character	Treatment	Nitrogen source			Time of water stress		
		2016			2017		
		Urea	A. nitrate	A. sulphate	Active tillering	Panicle initiation	Late booting
Straw yield (t/ha)	Duration of water stress						
	6DADWSS	17.54b	16.27d	17.75ab	17.16ab	17.26a	17.09ab
	8 DADWSS	17.45b	16.21d	17.92a	17.27a	17.24a	17.01b
	10 DADWSS	16.28d	15.57e	16.68c	16.21d	16.51c	16.30d
Harvest index	Duration of water stress	Nitrogen source (N)					
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
	6DADWSS	40.83b	40.80b	42.27a	39.00cd	40.34b	41.66a
	8 DADWSS	40.17cd	39.61d	40.27bc	39.39d	39.50bc	40.29b
	10 DADWSS	40.49bc	38.52e	40.18cd	39.79bc	38.39d	39.59bc
	Duration of water stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	40.88c	40.09d	42.70a	40.48ab	39.87b	40.66ab
	8 DADWSS	40.07d	38.50e	41.48b	39.57b	38.32c	41.29a
	10 DADWSS	40.16d	38.22e	40.81c	39.79b	38.04c	39.93b
Protein content	Time of water stress	Nitrogen source					
		Urea	A. nitrate	A. sulphate	Urea	A. nitrate	A. sulphate
	Active tillering	7.53bc	7.51bc	7.59bc	7.37cd	7.40cd	7.84b
	Panicle initiation	7.43c	7.14d	7.50bc	7.45cd	7.33d	7.49c
	Late booting	7.78ab	7.18d	7.89a	7.51c	7.50c	7.97a
	Duration of water stress	Time of water stress					
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
	6DADWSS	7.98b	8.13b	8.38a	7.99c	8.18b	8.60a
	8 DADWSS	7.53c	7.56c	7.54c	7.33e	7.54d	7.55d
	10 DADWSS	7.11d	6.38e	6.94d	7.28e	6.55g	6.83f

Means of each factor designated by the same latter are not significantly different at 5% level using DMRT.
DADWSS = Days after disappearance of water from soil surface.

season) gave the highest value of grain yield. Furthermore, combination of ammonium sulphate and withholding irrigation at late booting gave the highest value of protein content in both seasons.

The interaction between nitrogen sources and duration of water stress at identified growth stages significantly affected on 1000-grain weight, grain yield, straw yield, harvest index and protein content Tables 9 and10. The combination between irrigation withholding for 6 days and ammonium nitrate produced the highest value of 1000-grain weight, in the first season, and with ammonium sulphate in the second season. The duration of irrigation withholding for 6 days and ammonium sulphate gave the highest value of grain yield, harvest index and protein content in both seasons. The obtained high grain yield with ammonium sulphate are attributed to their beneficial role in improving soil, nutrient plant content and rice growth, grain yield attributes and main grain yield components. The interaction between time and duration of irrigation withholding at identified growth stages significantly affected on 1000-grain weight, grain yield, harvest index and protein content in both seasons (Tables 9 and 10). The combination between the duration of irrigation withholding for 6 days at late booting gave the highest value of 1000-grain weight, grain yield and protein content in both seasons as well as harvest index in first season. While, the duration of water stress of 8 days at late booting gave the highest value of harvest index in the second season.

C- Water input and productivity:

Comparing the different time and duration of water stress treatments Table 11, it was observed that, under all time of water stress treatments, withholding irrigation for 6 days received the highest amounts of water throughout the season, followed by 8 days water stress. While, the lowest amount of water input was received by withholding irrigation for 10 days. There were no large variations in the amounts of irrigation water input in both seasons due to the stable conditions; namely, temperature, relative humidity and evaporation rates. Among different duration of water stress treatments, the application of 8 days withholding at late booting stage was considered the best water productivity (0.939 and 0.929 kg/m^3). However, the minimum values of water productivity were obtained by 10 days water stress at panicle initiation stage (0.811 and 0.831 kg/m^3) in the two successive seasons Table 11. High water productivity, with 6 and 8 days water stress treatments, was associated with high grain yield and low water inputs in these treatments.

Table (11): Total water input and water productivity for EHR1 cultivar as affected by time and duration of water stress in 2016 and 2017 seasons.

Trait	Duration of water stress (days)	Time of water stress					
		2016			2017		
		Active tillering	Panicle initiation	Late booting	Active tillering	Panicle initiation	Late booting
Total water input (m^3/ha)	6	13340	13280	13410	13310	12950	12940
	8	12910	12840	12800	12870	12910	12880
	10	12550	12600	12520	12230	12200	12110
Water productivity (kg/m^3)	6	0.900	0.875	0.937	0.878	0.883	0.927
	8	0.889	0.854	0.939	0.880	0.834	0.929
	10	0.867	0.811	0.878	0.877	0.831	0.898

REFERENCES

A.O.A.C. (1970). Official Methods of Analysis. 11th Ed. Washington, D.C., USA.

Akram, H. M., A. Ali, A. Sattar, H. S. U. Rehman and A. Bibi (2013). Impact of water deficit stress on various physiological and agronomic traits of three rice (Oryza sativa L.) cultivars. The Journal of Animal & Plant Sciences, 23(5):1415-1423.

Assefa, M., F. Getnet, A. Menzir and H. Kurabachew (2009). Response of upland rice for nitrogen and phosphorus fertilizers on verticals of Pawe area. In: Proceeding of the 10th Conference of the Ethiopian Soc. Soil Sci. hold during 25-27 March, Addis Ababa, Ethiopia.

Castillo, E. G., T. P. Tuong, U. Singh, K. Inubushi and J. Padilla (2006). Drought response of dry seeded-rice to water stress timing and N-fertilizer rates and sources. Soil Science and Plant Nutrition, 52:496–508.

Chien, S., H. Gearhart, M. Mercedes and V. Saven (2011). Comparison of ammonium sulfate with other nitrogen and sulfur fertilizer in increasing crop production and minimizing environmental impact. J. of Soil. Sci., 76 (7): 327-335.

Crawford, N. M. (1995). Nitrate: Nutrient and signal for plant growth. The Plant Cell, 7, 859–868.

Davatgar, N., M.R. Neishabouri, A.R. Sepaskhah and A. Soltani (2009). Physiological and morphological responses of rice (*Oryza sativa* L.) to varying water stress management strategies. International Journal of Plant Production 3 (4):19-32.

Duncan, D.B. (1955). Multiple range and multiple *F* tests. Biometrics. 11:1-42.

Ebrahim, A., M. Khandan, H. R. Bozorgi, S. M. Sadeghi and M. Rezaei (2009). Response of rice varieties to water limit conditions in North Iran. World Applied Sciences Journal, 6 (9):1190-1192.

El-Refaee, I. S. (2011). Effect of timing and duration of water stress in different growth stages on productivity and grain quality of EHR1 hybrid rice cultivar. Agric. Res. Kafr El-Sheikh Univ., 37(4): 599-614.

El-Sharkawy, H. M., B. Zayed, T. Honna and S. Yamamoto (2006). Chemical compositions and salinity development in paddy soil as affected by irrigation intervals of mixed water under saline soil. Pakistan J. Biol. Sci.,9(4):741-745.

El-Wehishy, M. M. and A. G. Abd El-Hafez (1998). Response of flooded rice to water deficit. J. Agric. Res. Tanta Univ., Egypt, 23:273-288.

Fageria, N. K., A. B. Dos Santos and A. M. Coelho (2011). Growth, yield and yield component of lowland rice as influenced by ammonium sulfate and urea fertilization. J. of Plant Nutr., 34(3):371–386.

Fageria, N. K., A. B. Dos Santos and M. F. Moraes (2010). Influence of urea and ammonium sulphate on acidity indices in lowland rice production. Communicates in Soil Sci. and Plant Analysis 41:1565-1575.

Gomez, K. A. and A.A. Gomez. (1984). Statistical Procedure for Agricultural Research, 2nd Edition. A Wiley Inter science Pub., John Wiley and Sons, New York. USA. p.628.

Guo, S.W., G. Chen, Y. Zhou and Q.R. Shen (2007). Ammonium nutrition increases photosynthesis rate under water stress at early development stage of rice (*Oryza sativa* L). *Plant & Soil* 296 115-124.

Hafez, A.A. R. and D.S. Mikkelson (1981). Calorimetric determination of nitrogen for evaluating the nutritional status of rice.

Common. In Soil Sci. and Plant Analysis, 12(1):61-69.

Hassan, S.F., K.A. Hameed, A.H. Ethafa, A. Nadhimkadim, A. Y. Abbod, A.H. Ali and F.I. Khalil (2015). Response of three rice cultivars to intermittent irrigation in southern Iraq. Int. J. Applied Agric. Sci., 1(2):36-41

Jiang, P., L. Fen, X. Hong and J. Si (1993). Development of three high and one stable rice cultivation. Agric. Sci. and Technology, 1-13.

Juan, A. P. L. (2015). Acclamation of photosynthesis to water deficit and high temperature: Physiological and biochemical aspects. Ph.D. Thesis. Doctoral Program of Biology of the Plants. Univ. of Balears.

Kirk GJD and Kronzucker HJ (2005). The potential for nitrification and nitrate uptake in the rhizosphere of wetland plants: a modeling study. *Annals of Botany* 96 639-646.

Nurul, A., M. Zain, M. R. Ismail, M. Mahmood, A. Puteh and M. H. Ibrahim (2014). Alleviation of water stress effects on MR220 rice by application of periodical water stress and potassium fertilization. Molecules.19:1795-1819.

Roshan, N. M., M. Moradi, E. Azarpour and H. R. Bozorgi (2013). Irrigation withholding time management in four rice varieties at Guilan paddy fields (North Iran). African J. Agric. Res., 8(20):2371-2375.

Sekhar, D. P., V. N. Prasad, K. T. Rao and N. V. Rao (2014). Productivity of rice as by planting methods and nitrogen source. Int. J. Curr. Microbial. App. Sci., 3(8):1063-1068.

Shao, H. B., L.Y. Chu, C. A. Jaleel and C. X. Zhao (2008). Water-deficit stress-induced anatomical changes in higher plants. Plant biology and pathology. C. R. Biologies 331,El-Sevier :215–225.

Sikuku, P. A., G. W. Netondo, J. C. Onyango and D. M. Musyimi (2010). Effect of water deficit on physiology and morphology of three varieties of Nerica rained rice (*Oryza sativa* L.). ARPN J. Agric. Biological Sci.,5(1):23-28.

Sokoto, M. B. and A. Muhammad (2014). Response of rice varieties to water stress in Sokoto, Sudan Savannah, Nigeria. J. of Biosciences and Medicines.2:68-74.

Wang, M.Y., M.Y. Siddiqi and A.D.M. Glass (1993). Ammonium uptake by rice roots 1, Fluxes and subcellular distribution of 13 NH4+. *Plant Physiology* 103 :1249-1258.

Zain, N.A. M., M. R. Ismail, A. Puteh, M. Mahmood and M. R. Islam (2014). Impact of cyclic water stress on growth, physiological responses and yield of rice (*Oryza sativa* L.) grown in tropical environment. Ciência Rural, Santa Maria.44(12):2136-2141.

Zayed, B. A. (2012). Efficiency of different sulfur fertilizer sources in increasing hybrid rice productivity under saline soil conditions. Egypt. J. Agric. Res., 90(4):275-287.

Zayed, B. A., I.A. El-Saiad, S.M. Bassiouni and A.K. Salem (2013). Effect of different planting systems on soil water and rice productivity in the northern part of Delta in Egypt. J. of Soils Sci. and Agric. Eng., Mansoura Univ.,4(5):453-462.

Zayed, B.A., M.S.M. Abdel-Aal and G.A. Deweedar (2017). Response of rice yield and soil to sulfur application under water and salinity stresses. Egypt. J. Agron., 39(3):239- 249.

تأثير مصادر النتروجين والحرمان من الري عند مراحل نمو محددة للأرز الهجين تحت طريقة الزراعة التسطير

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الملخص العربى

أقيمت تجربة حقلية بمزرعة محطة البحوث الزراعية بمنطقة سخا – محافظه كفر الشيخ– مصر خلال موسمي الزراعة 2016 ، 2017 بغرض دراسة تأثير مصادر النتروجين والحرمان من الري عند مراحل نمو محددة للأرز الهجين ، وكان التصميم المستخدم القطع المنشقة مرتين فى أربعة مكررات حيث إحتوت القطع الرئيسية على مصادر النتروجين(اليوريا وسلفات الامونيوم و نترات الامونيوم) بينما إحتوت القطع الشقية الأولى على مواعيد الحرمان من الري عند مراحل نمو الأرز المختلفة وهى (مرحلة أقصى تفريع و مرحلة بزوغ الداليات وأيضا نهاية مرحلة الحبلانة). كما إحتوت القطع الشقية الثانية على ثلاثة فترات للحرمان من الري وهى (6 ، 8 ، 10 أيام بعد اختفاء الماء من سطح التربة) وذلك للصنف هجين مصري 1 المنزرع بطريقة التسطير وتتلخص أهم النتائج المتحصل عليها فى الآتي:

أثرت مصادر السماد النيتروجينى تحت الدراسة على صفات النمو ومحصول الحبوب ومكوناته حيث أعطى المصدر النيتروجينى سلفات الأمونيوم أعلى القيم بالنسبة لصفات النمو ومحصول الحبوب ومكوناته بالمقارنة بمصادر النتروجين الأخرى حيث سجلت نترات الامونيوم أقل القيم لمعظم الصفات المدروسة فى حين سجلت اليوريا قيما متوسطة و إحتلت المرتبة الثانية بين مصادر السماد النيتروجينى. وأثر الإجهاد المائي عند الحرمان من الري على صفات النمو ومحصول الحبوب ومكوناته حيث كان التأثير ضار جدا عند مرحله بداية تكوين الدالية وسجل الإجهاد المائي نتيجة الحرمان من الري عند مرحله أقصى تفريع تأثيرا متوسط على معظم الصفات المدروسة. و تشير النتائج أيضا إلى أن الحرمان من الري لمدة 10 أيام (بعد اختفاء الماء من سطح التربة) كانت أكثر تأثيرا على صفات النمو ومحصول الحبوب ومكوناته فى حين سجلت معاملة الحرمان من الري لمدة 6 أيام أقل تأثيرا وأعطت أفضل النتائج للصفات المدروسة. أثر التفاعل الثنائي معنويا على جميع الصفات المدروسة فى كلا الموسمين حيث أثبت المصدر النيتروجينى سلفات الأمونيوم كفاءته فى تقليل الإجهاد المائي على نبات الأرز خلال مراحل النمو المختلفة و أعطى الحرمان من الري لمدة 6 أو 8 أيام عند نهاية مرحلة الحبلانة (بعد اختفاء الماء من سطح التربة) اعلي إنتاجية لوحدة المياه. وتوضح النتائج أنه يمكن حرمان صنف الأرز هجين مصري 1 من الري لمدة 6 أيام (بعد اختفاء الماء من سطح التربة) عند مراحل النمو المختلفة دون النقص المعنوي لمحصول الحبوب.

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