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Influence of different sowing dates on growth and yield of direct seeded rice (*Oryza sativa L.*) in semi-arid zone (*Sudan*)

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Abstract

The aim of this study was to investigate the effect of different sowing dates on paddy yield and yield components of direct seeded rice (*Oryza sativa*) variety Nerica.4. The field experiments were carried out during two consecutive cropping seasons of 2008 and 2009 at White Nile Research Station Farm, Agricultural Research Corporation (ARC), Kosti, White Nile State, Sudan. Twelve successive sowing dates were conducted by the difference of 15-days between any sowing date and the next one. Eleven growth and yield characters were measured. The study was laid out in a randomized complete block design with three replications. The different sowing dates revealed significant effect on all the studied growth and yield characters. The results showed early sowing dates produce a high grain yield more than later ones, delaying sowing date from 15th July decrease the grain yield (t/ha), this may be attributed to the decrease of 1000 grain weight, number of filled grains/panicle and increasing of the percent of unfilled grains/panicle. The grain yield (t/ha) was positively and highly correlated with number of filled grains/panicle and 1000 grain weight. The sowing dates 1st July and 15th July produced the maximum grain yield of (2.9 t/ha^{-1}) and (2.8 t/ha^{-1}), respectively. It could be concluded that the period from the first of July to the mid of it can be considered as the optimum sowing date for direct seeding of the upland rice (variety Nerica.4) at Sudan and under White Nile State condition

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Introduction

Rice (*Oryza sativa* L.) is the most important and stable cereal crop on the global level, it is the main item of the diet of 3.5 billion people (Vivek *et al.*, 2004, Mahadi *et al.*, 2006, Bashir *et al.*, 2010 or Liu *et al.*, 2011). The world population is expected to reach 8 billion by 2030 and rice production must be increased by 50% in order to meet the growing demand (Khush and Brar, 2002, Kim and Krishnan, 2002). Sub Saharan African countries produce about 21.6 million tons of rice and they introduce 32% of the global rice market to fill the gap between their production and their demand (FAO, 2007, Somado and Guei, 2008). This was a result of population growth and the increasing of consumer preference in favor of rice in urban area (Kijima *et al.*, 2006, Atera *et al.*, 2011). Sudan has a total estimated potential rice area of more than 300.000 hectares, if this area is properly utilized it would suffice the local consumption of rice. Rice production constitutes the major economic activity and a key source of employment for the rural population at White Nile state in the Sudan; the crop is cultivated as irrigated and flood ecosystem in this State. Low yield of (0.98-1.2) t ha^{-1} were produced due to the using of traditional methods with low inputs that are not adequate to enhance productivity. The average yield of rice in the Sudan has been increased as a result of introducing and releasing new varieties but it is still far less than other leading rice-growing countries (AOAD, 2001). Achieving a sustainable increase in rice production can improve global food security and contribute to poverty alleviation (Mohamed, 2010). Rice scientists are engaged in developing new high-yield varieties and management practices to increase the productivity per unit area. The reason for such low yield is mainly associated with cultural technologies. Planting rice in the optimum period of time is critical to achieve high grain yield. However, optimum rice planting dates are regional and vary with location and genotypes (Bashir *et al.*, 2010). Bruns and Abbas (2006) and Yoshida (1981) reported that rice plants require a particular temperature for its phonological affair such as panicle initiation, flowering, panicle exertions from flag leaf sheath and maturity. Rice seeded before the window of optimum dates usually has slow germination and emergence, poor stand establishment, increased damages from soil borne, seedling diseases under cold conditions and seeds lose by birds or mice (Linscombe *et al.*, 1999). Planting rice after the optimum dates can result in low yield due to higher disease and insect incidence, tropical storm-related lodging and possible heat or cold damage during heading and the grain filling period (Groth and Lee, 2003 and Reza *et al.*, 2011). Seedling at the time of transplanting is an important factor for uniform stand establishment of rice. On the other hand, if the age of seedlings is more than optimum, the seedlings produce fewer tillers due to the reduction of vegetative period and thereby result in poor yield. Among the crop production tools, proper time and method of sowing are the prerequisites that allow the crop to complete its life phase timely and successfully under a specific agro-ecology (Vange and Obi, 2005, Bashir *et al.*, 2010). Khalifa (2009) concluded that early date of sowing is the appropriate time for gaining important properties such as the maximum tillers, number of tillers per m^{-2}, plant height, 1000 grain weight and grain yield. The number of kernel per panicle show, a better response with early sowing because late sowing, shortened the growth period of the plant and therefore reduced the leaf area, length of panicle and number of kernels per panicle. Yawinder *et al.*, (2006) and Bashir *et al.* (2010) reported that a thousand grain weight decreased gradually with delay in planting time. Khakwani *et al.*, (2006) explained that grain yield was significantly influenced by sowing time. Therefore, the main objectives of this study were to investigate and evaluate the influence of different sowing dates on paddy yield and yield components and the correlation between these traits of upland rice (Variety Nerica.4) through two successive growing seasons at Kosti city, White Nile State, Sudan.

Materials and methods

The study was conducted in the Sudan at the Agricultural Research Corporation (ARC), White Nile Research Station Farm (WNRS) at Kosti city, (longitude 33° 29′ E and latitude 14° 24′N). The soil of the experimental plots was classified as vertisol with high clay content (40-65%), less than 1% organic carbon, low in available nitrogen (0.03% total nitrogen), medium in available P_2O_5(406 to 700 ppm total phosphorus) and pH values ranging from 7 to 8.2. The climate of the location is considered as semi-arid. The rice variety NERICA.4 was introduced from Uganda in season 2006/07 by the FAO for the TCP/SUD/3101 (T) project, "Training on Improved Rice Technologies for the Enhancement of Irrigated Rice Production" in the White Nile State, Sudan (Africa Rice Center (WARDA)/FAO/SAA 2008). This variety was recomended by the Agricultural Research Corporation (ARC), Sudan, after preliminary yield tests selection based on yield components, early maturity, adapted to high temperature and general performance, therefore, it was used in this study as a reference variety. The two experiments were conducted in two successive years (July to December 2008 and July to December 2009) in different twelve successive sowing dates by the difference of 15-days between any sowing date and the next one viz. : (1st July , 15th July , 1st August , 15th August ,1st September , 15th September ,1st October, 15th October ,1st November , 15th November ,1st December and 15th December) (Fig. 1.). The design of the experiment was a randomized complete block design (RCBD) with three replications. The plot size was 5m × 5m and consisted of 25 rows spaced 20 cm apart. The seeds were sown with a single row hand drill using a seed rate of 120 kg/ha. The fertilizers were applied at the rate of 86 and 43 kg/ha^{-1} in of the form of urea and triple super phosphate, respectively. The triple super phosphate was applied as a basal dose during final land preparation and the urea was top dressed in two equal split doses one at 21days after sowing and the other before panicle initiation. Hand weeding was performed three times per season. All plots were irrigated at sowing and then the irrigation was scheduled every 5 to 7 days intervals until the plants at each plot reached maturity.

Data were collected for days to 50% flowering (days from sowing to time when 50% of the plants start to flowering) and days to maturity (days from sowing to time when panicles reached full maturity). At harvest, 10 plants in the middle rows of each plot were randomly selected and used for measuring of the following characters *viz.* plant height (cm), panicle length (cm), number of panicles/m^2, number of tillersplant^{-1}, number of filled grains/panicle^{-1}, percent of unfilled grains panicle^{-1}, 1000 grain (paddy) weight (g), grain (paddy) yield (t/ha) and biological yield(t/ha). The data were collected according to standard evaluation systems (SES) for rice, IRRI (1988).

Statistical analysis

Analysis of variance (ANOVA) was carried out on the data of every season separately to assess the sowing date effect and their interaction using a general linear model (GLM) procedure for randomized complete block's design in Statistical Analysis Software, (SAS, 1997).

Estimates of variance components were generated and combined analysis of variance was done for the characters in which the mean squares were homogenous, the mean of values were compared by Duncan's Multiple Range Test (DMRT) according to Gomez & Gomez (1984). The two seasons were used to compute simple linear correlation coefficients.

Results and discussion

The results of the separate analysis of variance and the range means of different characters of rice obtained from the twelve sowing dates for both seasons (2008 and 2009) are presented in Table 1. These results revealed significant differences between the 12 sowing dates for yield and yield components. This variability indicates the effect of environmental factors on different characters and gave a sign to obtain and select the optimum sowing date across wet and dry seasons of Sudan. Substantial variations in the effect of different sowing dates in rice yield and yield components had been reported by many researchers, e.g. (Shah and Bhurer, 2005 , Vange and Obi, 2009 and Khalifa *et al.*, 2014).

Table 1. The separate analysis of variance and the range means for growth and yield characters of rice(Variety Nerica.4) obtained from the 12 sowing dates for the two seasons (2008 and 2009) grown at (WNRS) farm Sudan.

Seasons	2008				2009			
Variables	range	mean	F value	C.V	range	mean	F value	C.V
Days to 50% flowering	55-83	72.5	8.5***	2.1	64-83	72.9	27.6***	3.9
Days to maturity	83-107	94.9	14.2**	2.8	84-107	92.9	16.8***	1.5
Plant height (cm)	49-93	69	41.1***	5.8	51-93	70.4	38.3**	5.7
Panicle length(cm)	13-21	17.2	25.3**	5.1	13-24	17.6	15.0**	7.8
Number of panicle/m²	219-398	306	12.1*	7.6	233-398	324.5	8.6**	7.6
Number of tillers/plant	3-5	3.9	13.2*	9.7	3-5	3.9	4.3*	13.4
Number of filled grains/panicle	15-71	37.7	60.0***	7.2	29-72	47.3	20.7***	11.1
Percent of unfilled grains/panicle	17-71	43.6	69.7***	8.6	14-73	43.8	39.2***	11.9
1000 grain weight (g)	20-38	26.5	21.5***	6.3	22-35	27.3	51.9**	3.2
Grain yield (t/ha)	0.5-3.0	1.58	13.2**	9.7	0.5-3.1	1.60	4.3**	13.4
Biological yield(t/ha)	3.0-9.0	5.75	12.1**	7.6	3.0-11.0	5.80	8.6**	7.6

*, **,*** Significant at 0.05,0.01 and 0.001 probability levels, respectively.

Table 2a. Means of the combined values of the two seasons (2008 & 2009) for growth and yield characters of rice (Variety Nerica.4) obtained from 12 sowing dates grown at the (WNRS) farm Sudan.

sowing date	DAF	DAM	PLH(cm)	PL(cm)	NTP	NPM
1st July	72.8^{BCDE}	92.7^{DE}	91.7^{A}	21.0^{A}	4.5^{AB}	347.8^{AB}
15th July	67.8^{E}	96.5^{BC}	90.0^{A}	21.0^{A}	4.3^{ABC}	367.8^{A}
1st August	69.5^{DE}	96.2D^{EF}	89.0^{A}	19.7^{A}	4.8^{A}	353.5^{AB}
15th August	69.7^{CDE}	93.5^{CD}	78.3^{B}	19.8^{A}	4.7^{AB}	345.5^{AB}
1st September	70.8^{CDE}	89.8^{EF}	75.3^{B}	19.8^{A}	4.2^{ABCD}	350.3^{AB}
15thSeptember	72.0^{CDE}	88.7^{F}	66.2^{C}	17.2^{B}	3.3^{EF}	333.8^{AB}
1st October	74.7^{BC}	88.7^{F}	60.5^{D}	16.2^{BC}	3.7^{CDEF}	3.21.0^{BC}
15thOctober	72.0^{CDE}	89.7^{EF}	61.0^{D}	15.3^{CD}	4.0^{BCDE}	299.2^{CD}
1st November	71.0^{CDE}	92.5^{DE}	57.8^{D}	15.8^{BC}	3.7^{CDEF}	286.8^{CDE}
15thNovember	73.7^{BCD}	96.8^{B}	57.8^{D}	15.3^{CD}	3.5^{DEF}	253.7^{EF}
1st December	81.7^{A}	104.0^{A}	59.0^{D}	13.8^{D}	3.0^{F}	250.3^{F}
15thDecember	77.0^{B}	104.5^{A}	51.3^{E}	13.8^{D}	3.5^{DEF}	276.7^{DEF}
General mean	72.72	93.95	69.83	17.41	3.93	315.54
F value	5.9***	25.7***	70.4**	28.7**	5.1*	12.4**
C V %	5.2	2.8	6.1	7.2	16.0	9.2

Means followed by the same letter(s) within a column are not significantly different at 0.05 probability level according to the Duncan's Multiple.

Range Test, days to 50% flowering (DAF), days to maturity (DAM), Plant height (PHT), panicle length (PL) and number of panicles/m² (NPM).

The Means of the combined values (of the two seasons 2008 & 2009) for growth and yield characters of rice (Variety Nerica.4) obtained from 12 sowing dates in this study are presented in tables 2a and 2b. For Days to flowering, the earliest flowering (67.8 days) and the latest (81.7 days) were obtained from the sowing dates 15th July and 1st December, respectively (Table, 2a). Generally, it seems that early flowering dates up to September 15th produce early flowering days and maturity. On the other hand, late sowing dates produce late flowering and maturity. These results reflect the effect of temperature from high to low (Fig. 2.) on delaying flowering and maturity in rice, therefore this character can be considered as an indicator for the heat stress (effect) in rice flowering and maturity. Similar results were reported by Bashier *et al.* (2010). The plant height was affected significantly by the different sowing dates. Plant height decreased significantly when sowing days were delayed. The sowing dates 1st July, 15th July and 1st August produced the maximum plant height (91.7, 90.0 and 89.0) cm, respectively. (Table, 2a). The lowest plant height (51.3 cm) was produced from the last sowing date (15th December). Sowing dates from 1st October to 1st December produced statistically similar and shorter plant heights while before 1st October they produce statistically different plant heights. It is obvious that the reduction in plant height in late sowing dates could be attributed to the effect of low temperature and low humidity in the dry season (Fig. 2).

Table 2b. Means of the combined values of the two seasons (2008 & 2009) for growth and yield characters of rice (Variety Nerica.4) obtained from 12 sowing dates grown at the (WNRS) farm Sudan.

sowing date	NFP	UFP %	SGW(g)	$GYth^{-1}$	$BYth^{-1}$
1st July	69.0^{A}	17.7^{F}	31.0^{BC}	$2.9.^{A}$	8.7^{A}
15th July	68.0^{A}	18.7^{F}	32.5^{AB}	2.8^{A}	7.0^{BC}
1st August	66.7^{A}	20.7^{F}	33.0^{A}	2.2^{B}	7.0^{BC}
15th August	48.3^{B}	34.7^{E}	30.0^{C}	2.3^{B}	7.0^{BC}
1st September	41.2^{C}	39.5^{DE}	30.0^{C}	1.7^{C}	7.2^{B}
15thSeptember	36.5^{CD}	43.2^{D}	24.5^{DE}	1.6^{C}	4.5^{EFG}
1st October	36.8^{CD}	44.5^{D}	24.5^{DE}	1.3^{D}	4.7^{EF}
15thOctober	33.7^{DE}	50.0^{C}	23.8^{DEF}	1.3^{D}	4.3^{FG}
1st November	31.3^{DEF}	56.0^{B}	22.5^{F}	0.8^{E}	3.7^{FG}
15thNovember	28.8^{EFG}	64.3^{A}	23.5^{DEF}	0.9^{E}	3.5^{G}
1st December	25.3^{FG}	67.7^{A}	23.0^{EF}	0.8^{E}	5.5^{DE}
15thDecember	24.3^{G}	68.0^{A}	25.0^{D}	0.6^{F}	6.0^{CD}
General mean	42.50	43.74	26.94	1.59	5.75
F value	61.9**	109.1**	42.9**	174.1***	174.4**
C V %	12.2	9.8	5.5	9.3	9.2

Means followed by the same letter(s) within a column are not significantly different at 0.05 probability level According to Duncan' Multiple.
Range Test. number of tillers/plant (NTPP), number of filled grains/panicle (NFGPP), percent of unfilled grains/panicle (PUGPP),1000 grain weight (TGW), grain yield (GYt/ha).and biological yield (BYt/ha).

These results are in line with (Khakwani *et al.* 2006, Akram *et al.*, 2007) whom reported that plant height was significantly affected by sowing dates and early sowing dates of rice produce taller plants more than delayed sowing dates. The results of Panicle length (cm) showed that it was also significantly affected by different sowing dates. The sowing date 1st July produced the maximum Panicle length (21.0 cm). Panicle length decreased significantly by the delaying of sowing dates. The lowest Panicle length (13.8 cm) was observed for the sowing date 15th December (Table 2a). Plants sown on July 1st, July 15th, August 1st, August 15th and September 1st produced statistically similar and longer panicle lengths, while the late sowing dates produce statistically different and shorter panicle lengths. The reduction in panicle length for late sowing dates could be attributed to the effect photoperiod and temperature according to the fact that rice is considered as a summer and short day crop; these findings are in conformity with those of (IRRI, 1993, Faghani, 2011). In this study, the highest range of number of tillers/plant (from 4.3 to 4.8.) were exhibited for the planting dates 1st July, 15th July, 1st August, 15th August, 1st and September 1st. On the other side, the lowest range of number of tillers/plant (from 3.0 to 3.7) were exhibited for planting dates 1st October, 1st November, 15thNovember, 1st December and 15thDecember (Table

2a). These results indicate that early sowing dates produce more tillers\plant than late sowing dates. High number of effective tillers/plant is important factor in selection the optimal sowing date due to the fact that this character is indicator for production of high yield in rice. It is evident in the data that number of panicles per meter square was affected significantly by different sowing dates. The crop sown on 1st July, 15th July, 1st August, 15th August, 1st and September 1st produced the maximum number of panicles per meter square (347.8-367.8). The lowest number of panicles per meter square (250.3) was observed for the sowing date 1st December. This showed that total number of productive tillers gradually decreases as the sowing was delayed after 1st September. This increase in the number of productive tillers per plant and a number of panicles per meter square on July 1st, July 15th, August 1st and August 15th sowing was attributed due to the favorable environmental conditions which enabled the plant to improve its growth and development as compared to late sowing dates. These results are similar to that of (Akbar *et al.,* 2009), they indicated that different sowing dates had a significant effect on the number of fertile tillers per meter square. These results are also in line with Rakesh and Sharma (2004) who reported that delaying in planting in rice resulted in significant decrease in a number of productive tillers per meter square and ultimately the paddy yield.

Table 3. Simple linear correlation coefficients between 11 pairs of traits in rice using season 2008 (above the diagonal) and season 2009 (below the diagonal).

Traits	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11
x1		0.45**	-0.58***	-0.57***	-0.43*8	-0.45**	-0.64***	0.62***	-0.50**	-0.51**	-0.22ns
x2	0.67**		-0.34*	-0.43*	-0.07ns	-0.35*	-0.37*	0.51*	-0.18ns	-0.37*	-0.05ns
x3	-0.29**	-0.27ns		0.82***	0.63**	0.77**	0.95**	-0.90*	0.81*	0.92*	0.72*
x4	-0.42**	-0.35*	0.87***		0.70***	0.81*	0.81**	-0.85**	0.78*	0.86*	0.59*
x5	-0.30*	-0.38*	0.42**	0.52**	1	0.62***	0.63**	-0.54*	0.75*	0.58*	0.64*
x6	-0.48**	-0.56**	0.58***	0.52**	0.55**		0.76**	-0.78**	0.79**	0.77**	0.64**
x7	-0.18ns	-0.22ns	0.88***	-0.60**	0.68**	-0.84*		-0.92**	0.84**	0.93*	0.67**
x8	0.37*	0.37*	-0.86**	0.38*	-0.52**	0.82***	-0.84*		-0.81***	-0.90***	-0.63**
x9	-0.28*	-0.15ns	0.88**	0.54**	0.64**	0.88**	0.93**	0.82**		0.83**	0.74**
x10	-0.37*	-0.32ns	0.92*	0.26ns	0.27*	0.60**	0.65**	-0.69**	0.82**		0.65***
x11	-0.06ns	0.05ns	0.66**	0.52**	0.55**	-0.84*	-0.84*	0.82**	0.69**	0.70**	

*, **,*** Significant at 0.05, 0.01 and 0.001 probability levels, respectively. ns= not significant. N = 52

X_1: Days to 50% flowering X_2: Days to maturity X_3: Plant height (cm) X_4: Panicle length (cm) X_5: No. of panicles/m² X_6: No. of tillers/plant.

X_7: No. of filled grains/panicle X_8: unfilled grains/panicle (%) X_9: 1000 grain weigh (g) X_{10}: yield (t/ha) X_{11} :Biological yield (t/ha).

The data regarding the number of filled grains per panicle showed that it was affected significantly by different sowing dates. The sowing date 1st July produce the maximum number of filled grain per panicle (69.4) followed by July 15th (68.0) and 1st August (66.7). The lowest number of filled grain per panicle (24.3) was observed for the sowing date 15th December. This showed that number of filled grain per panicle gradually decreases with the delaying of sowing date after 15th August (Table 2b). The results of 1000 grain weight(g) took the same trend of the results of number of filled grains per panicle in producing high 1000 grain weight(g) in the early sowing dates and low1000 grain weight(g) in the late sowing dates (Table 2b). These two characters are considered as the most important yield components in rice grain yield (IRRI, 1993). These findings are similar to that of Akram *et al.* (2007), Kameswara and Jackson (1997) and Tari *et al.* (2007) who reported that number of kernels per panicle were significantly affected when the sowing date is delayed. Also these results are similar to that of Bashier *et al.* (2010) and Shah and Bhurer (2005) who reported that more number of filled grains per panicle was visualized in the early seeding and declined gradually in the successive seeding dates. However, these results are in contrary to that of Habibullah *et al.* (2007), who reported that sowing date had no significant effect on a number of grains per panicle. In this study the lowest percent of unfilled grains/panicle (17.7-20.7) were given by the early sowing dates of July 1st, July 15th and August 1st. On the other hand, the late sowing dates from September 1st up to December 15th with their unfavorable weather conditions (low temperatures and relative humidity) (Fig. 1) were resulted in obtaining high Percent of unfilled grains/panicle (39.5-68.0) as shown in (Table 2b). This high percentage of unfilled grains/panicle in these late sowing dates could be attributed to reduction of spikelet fertility or increasing of spikelet sterility in this period. These results are similar to that obtained by Akram *et al.*, (2007). For the biomass production, this character scored the highest values at 1st July sowing date compared with the other's sowing dates. The difference between the highest and lowest dry matter production was 2.7 $t.ha^{-1}$. The reduction in biomass production with delay in sowing was also reported by Akram *et al.*, (2007).

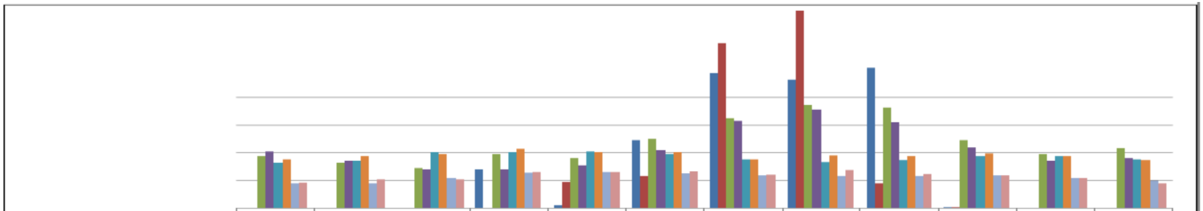
The data regarding the paddy grain yield ($t.ha^{-1}$) are shown in Table 2b. It is evident that grain yield ($t.ha^{-1}$) was affected significantly by different sowing dates. The grain yield ($t.ha^{-1}$) decreased when the sowing date delayed after 1st August. The sowing dates 1st July and 15th July produced the maximum grain yield (2.9 $t.ha^{-1}$) and (2.8 $t.ha^{-1}$), respectively. The lowest grain yield (0.6 $t.ha^{-1}$) was obtained by the last sowing date (15th December). The higher yield in case of sowing dates 1st July and 15th July was attributed to increase the cumulative mean value of appropriate temperature and sunshine hours which resulted in more number of productive tillers/plant, more number of kernels per panicle, increase of 1000-kernal weight and accordingly high yield ($t.ha^{-1}$). These results are in line with that of (Iqbal *et al.*, 2008) and (Osman *et al.*, 2012) who reported that the high yield in rice could be obtained when it sown at an optimal sowing date.

Table 4. Economic analysis regarding the effect of different sowing dates on yield and yield components of direct seeded rice.

sowing date	Gross income (SDG)	Total expenditure (SDG)	Net benefit (SDG)
1st July	6478	1568	4910
15th July	6254	1563	4691
1st August	4914	1533	3381
15th August	5138	1538	3599
1st September	3797	1508	2289
15thSeptember	3574	1503	2071
1st October	2904	1488	1416
15thOctober	2904	1488	1416
1st November	1787	1463	324
15thNovember	2010	1468	542
1st December	1787	1463	324
15thDecember	1340	1453	-113

* The Cost of production dependent on the previous study by El Awad, A. 2008. TCP/SUD/3101 (T) project, "Training On Improved Rice Technologies for the Enhancement of Irrigated Rice Production in the White Nile State, Kosti, Sudan (SDG): Sudanese Genih (Pound).

The data regarding the simple correlation coefficient over two seasons are given in Table 3. It is evident the associations between characters could of a benefit in understanding the influence of different sowing dates in rice paddy yield and yield components. The simple correlation coefficient of paddy grain yield t/h with a plant height (cm), number of tillers/plant, number of panicles/m^2, number of filled grains/panicle, 1000 grain weight was positive and significant, indicating that the strong simple correlation coefficient between grain yield t/ha and traits on two seasons. While Grain yield was negatively and significantly correlated with percent of unfilled grains/panicle, because an increase in the percent of unfilled grains/panicle decreased grain yield. Similar results were reported by Mehetre *et al.,* (1996). Number of tillers/plant was positively and significantly correlated with 1000 grain weight and number of filled grains/panicle. Number of panicles/m² was positively and significantly correlated with the number of filled grains/panicle and 1000 grain weight. Negative correlation was noticed between percent of unfilled grains/panicle with the number of tillers/plant, number of grains/panicle and number of filled grains/panicle may be due to their high correlation with grain yield. These results agreed with that reported by Prasad *et al.,* (2001) and (Mohamed *et al.*, 2012).



	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Rainfall (Mm)2008	0	0	0	28.1	2.2	48.8	97.7	92.8	101.4	1	0	0
Rainfall (Mm)2009	0	0	0	0.1	19	23.2	119.4	142.6	18.2	0.8	0	0
R.H. % 2008	38	33	29	39	36	50	65	75	73	49	39	43
R.H. % 2009	41	34	28	28	31	42	63	71	62	44	34	36
Max.Temp.(C)2008	32.9	34.1	40.9	40.4	41.2	39	35.5	33.2	34.6	37.4	37.8	35.5
Max.Temp.(C)2009	35.2	37.7	39	42.9	40.7	40.8	35.5	38.2	37.4	39.5	37.3	34.6
Min.Temp.(C)2008	17.8	17.8	21.9	25.5	25.9	25.1	24	23.2	22.9	23.4	21.7	19.9
Min.Temp.(C)2009	18.7	20.6	21	25.9	26	26.5	24.3	27.5	24.8	23.6	21.8	17.9

Fig. 1. Monthly means of meteorological data record during 2008 and 2009 at Kosti Meteorological Station.

Economic Analysis

A brief overview of the Table 4 indicated that maximum net income of SDG 4910 was recorded for when rice was sown on 1st July. High net income was due to high paddy yield and straw yield as well as due to fewer pest attacks thereby reducing the additional cost of inputs in terms of pesticide application. This was followed by the rice sown at 15th July, 1st August and 15th August giving net income of SDG 4691, 3381 and 3599, respectively. The minimum net income of SDG 2071 was observed when rice was sown on 15thSeptember. However a loss of SDG 113 was observed when the rice was sown on 15thDecember. This showed that the net benefit gradually decreased as sowing was done after 1st September and later on. Seeding rice before the predicted optimum periods would lengthen the time between seeding and emergence; increase production costs from the use of recommended seed treatments, higher seeding rates; a longer period for pest control and possibly result in poor stand establishment .

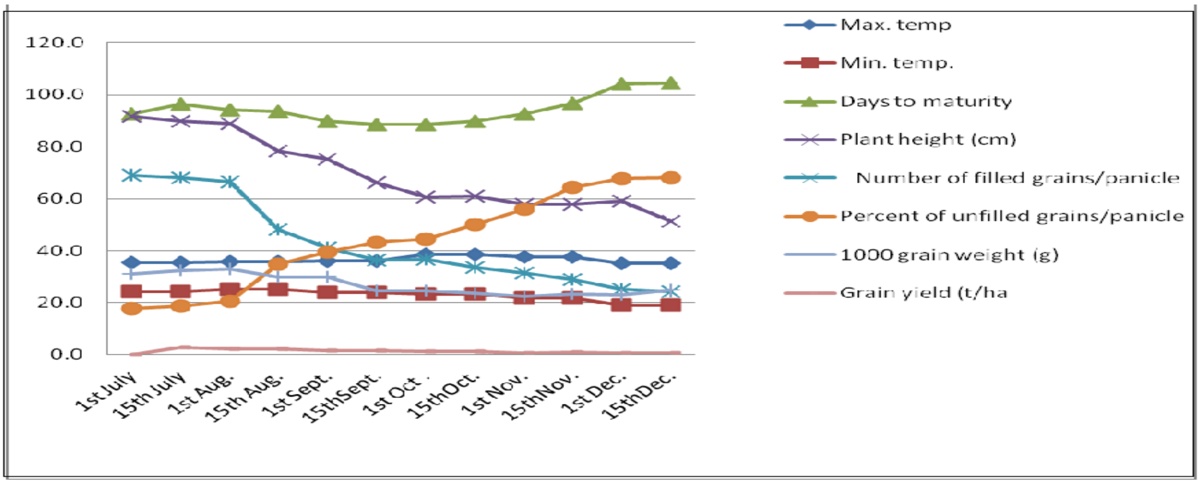


Fig. 2. The interaction of temperitures and yield and its components.

Conclusion

Based on results of this study, it could be concluded that the early sowing dates resulted in less days to 50% flowering, days to maturity and percent of unfilled grains panicle^{-1}. On the other side early sowing dates resulted in increase of plant height, panicle length, number of panicles/m^2, number of tillers/plant^{-1}, number of filled grains/panicle^{-1}, 1000 grain (paddy) weight, grain (paddy) yield and biological yield. The sowing dates 1st July and 15th July produced the maximum grain yield of (2.9 t/ha^{-1}) and (2.8 t/ha^{-1}), respectively. Therefore, they can be selected as the optimum sowing dates for direct seeding of upland rice varieties, in the White Nile State, (Sudan).

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