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Physiological Indices of Direct Seeded Upland Rice (*Oryza species*) Varieties as Affected by Seed Rates

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Abstract: ***Field trials were conducted at Samaru and Maigana during the 2011 and 2012 wet seasons on the experimental farm of the Institute for Agricultural Research, Ahmadu Bello University Samaru, Zaria and on the Research Farm of the Kaduna State Agricultural Development Programme, Maigana both in the Northern Guinea Savannah agro-ecological zone of Nigeria to determine the physiological indices of direct seeded upland rice varieties as affected by seed rates. The treatments consisted threesowing methods (Broadcasting, Drilling and Dibbling), three upland rice varieties (NERICA 4, 8 and JAMILA) and three seed rates (40, 80 and 120 kg ha^{-1}). The treatments were laid out in a split plot design and were replicated three times with factorial combinations of sowing methods and seed rates in the main plots and three rice varieties in the sub plots. Results revealed that 40 and 80 kg ha^{-1} had higher values for CGR, NAR andRGR at both locations. The seed rates of 40 and 80 kg ha^{-1} significantly delayed heading and physiological maturity at both locations but seed rates did not significantly affect relative growth rate and shoot dry weight at both locations. Sowing method significantly influenced crop growth rate, shoot dry weight and days to 50 % heading only at Samaru where broadcasting and drilling methods recorded higher crop growth and shoot dry weight over dibbling method. However, dibbling method had higher crop growth rate than broadcasting and drilling methods only at Maigana while at Samaru, dibbling delayed in days to 50% heading. Thoughdibbling method delayed in days to 50% heading but was ststistically at par with drilling and drilling in turn was at par with broadcasting method. There was no significant influence of sowing methods on relative growth rate at both locations. There were significant variation and similarity among the varieties used in this study. It was observed that at both locations, JAMILA delayed in days to 50% heading and therefore matured late while NERICA 8 had the highest crop growth rate and shoot dry weight. However, NERICA 4 and 8 displayed similarities in crop growth and shoot dry weight. Based on the result obtained from the study, it can be inferred that JAMILA matured later than NERICA 4 buthad higher physiological indices in Samaru while NERICA 8 perform better in Maigana. Consequently broadcast or drilled rice performed better at 40 kg ha^{-1} seed rate.***

Keywords: physiological, Indices, direct seeded rice varieties and seed rates

1. Introduction

Determination of physiological indices of rice is necessary. Plant physiologists apply growth indices as useful tools for the analysis of growth in different areas of specializtion such as plant breeding, plant ecology and physiology. Some indices that are measured in rice studies are its Crop Growth Rate (CGR), Relative Growth Rates (RGR) and Net Assimilation Rate (NAR) [1]. The CGR is the best criterion of the physiological analysis in rice. The most CGR in rice was reported between 30 to 36 g m^{-2} in Philippine and Japan conditions. [2] reported that in early maturity lines, the CGR increases before flowering had significant correlation with grain yield while in the late maturity lines, CGR increases after flowering had significant correlation with yield.[3] indicated that grain yield in rice had positive correlation with LAI, CGR and NAR while [4]indicated that in all of phonological stages in direct seeding and transplanting methods of rice, the NAR had positive correlation with the grain yield but at 70 and 85 days after planting, the NAR had no significant effect on the grain yield. However, [5] reported that grain yield had significant correlation with tiller number and total dry matter (TDM). Identification of growth physiological indices in analysis of factors affecting yield and its components has a great importance and its stability to determines the dry matter production which is a criterion of yield components and in this regard leaf area index, total dry weight (TDW) and leaf dry weight (LDW) should be measured in periodic intervals during the growing season [6]. The above indices plus crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), leaf area duration (LAD), leaf area rate (LAR), Leaf weight rate (LWR) and specific leaf area rate (SAR) are indices which often used for evaluation of plant productivity capability and environmental efficiency [7][8]

Direct seeding of rice refers to the process of establishing the crop from seeds sown in the field rather than by transplanting seedlings from the nursery [9]. Direct seeding avoids three basic operations, namely, puddling (a process where soil is compacted to reduce water seepage), transplanting and maintaining standing water.[10] evaluated the effect of planting methods on growth and yield of Digang rice (*Oryza sativa L)* under upland condition of Bawku, Ghana and the result revealed that planting methods had significant effect on growth and yield component but differences in years and plot locations were not significant. With the exception of transplanting method, the other planting methods did not have significant effect on germination and plant height. The direct seeding of dibbling and drilling methods had better plant establishment and was significantly higher than pre-germinated seed broadcasting and seedling transplanting methods. Straw dry matter was higher in direct seed dibbling and transplanting methods and both were significantly different from direct drilling and pre-germinated seed broadcasting methods. [11] studied rice variety as influenced by sowing methods and nitrogen rates and reported that plants established by broadcasting had more rapid leaf area development, dry matter accumulation and N uptake than transplanted plants during vegetative growth stages, but slower growth rates and N uptake after panicle initiation,

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particularly during grain filling period.[12] Studied the responses of seeding rate of new durum cultivars at three locations in Southern Australia and found that there were no significant differences in variety responses to seed rates which imply that the varieties exhibit a high similarity for response to input levels and also the overall effect of altering seed rate depend mainly on interactions with the environment. On the other hand, seeding rate had no significant effect on grain yield or quality during harsh grain filling conditions (heat stress) but in more favourable higher yielding environment, higher seed rates (200-250 seeds m^2) consistently yielded higher across all the sites. [13] reported a significant decrease in leaf area index and dry matter production with the increase in seedling density from the sowing rate of 20 to 60 g m^2 in the nursery.[14] conducted an experiment to determine the Physio-Morphological attributes in ralation to yield potential of Modern and aromatic rice varieties. The result showed that aromatic rice varieties had the tallest plant stature, profuse tillers $hill^{-1}$, panicle $hill^{-1}$, larger grains, higher grain yield, lowest straw yield and harvest index while the modern varieties had higher values for total dry matter, leaf area index, crop growth rate, relative growth rate and that aromatic varieties also resulted in higher net assimilation rate.[15] studied growth and yield of rice (*Oryza sativa* L) varieties as influenced by different methods of planting under aerobic method of cultivation and reported that among the varieties MAS 26 recorded significantly higher values for such growth parameters as number of leave area and total dry matter accumulation. The objectives of this experiment was to determine the physiological indices of direct seeded upland rice varieties as affect by seed rates.

2. Materials and Methods

The field trials were conducted on the experimental farm of the Institute for Agricultural Research, Ahmadu Bello University Samaru, Zaria and on the Research Farm of the Kaduna State Agricultural Development Programme, Maigana in 2011 and 2012 cropping seasons. Samaru is on the Latitude 11^o11^1 N and Longitude 7 $^o38^1$ E and is 686 m above sea level while Maigana is located on Latitude $11^o11.06^1$ N and Longitude $7.54^o7.58^{1\ E}$ both in the Northern Guinea Savannah Agro ecological zone of Nigeria. Random samples of soils were taken at depth of 0-30cm from the experimental sites using an auger of 10cm diameter before land preparation and were analysed for physical and chemical properties. The treatments consisted of three seeding methods (broadcasting, drilling and dibbling), three seed rates (40, 80 and 120 kg ha^{-1}) and three upland rice varieties (NERICA 4, 8 and JAMILA) and were laid out in a split plot design with the factorial combinations of sowing methods and seed rates in the main plots and three rice varieties in the sub plots measuring 3 m x 3 m with a net plot of 2 m x 2 m and were replicated three times. The main plots were separated by a distance of 1 m and the sub plots by 0.5. Preplanning herbicides, glyphosate (round up) was applied two weeks before land preparation in each year of the study to the experimental sites at the rate 2 kgactive ingredients ha^{-1} in order to control the prevalent weeds on the field. Thereafter, the field was harrowed twice to ensure fine tilth of the soil and the soil levelled manually. Seeds of each variety were treated with Apron star as seed dressing chemical at the rate of 1.0 g of metalaxy to 3.0 kg seed to prevent pest attack and the three rice varieties were planted on 13th July 2011 and 9th June 2012 at Samaru while at Maigana, the varieties were planted on 30th July 2011 and 12th June 2012 when the rains were fully established using direct seeding such as broadcasting, drilling and dibbling methods. Also hand pulling methods of weed control was used to control the weeds that later emerged at four and eight weeks after sowing. Fertilizers were applied at the recommended rate of 100 kg N ha^{-1},50kg P2O5ha^{-1} and 50 kg K_2O ha^{-1}. The nitrogen fertilizer were applied as split, half of the nitrogen fertilizer together with 50 kg P_2O_5 and 50 kg K_2O ha^{-1} were applied once at two weeks after planting using NPK (15:15:15) while the second half of the nitrogen were applied at panicle initiation stage using urea (46% N). Data were collected on the following parameters; crop growth rate (CGR), relative growth rate (RGR) , net assimilation rate (NAR) shoot dry weight (SDW) , days to 50% heading and days to 50% maturity were analysed using a General Linear Model in SAS and Duncan Multiple Range Test was used to separate the treatment means [16].

3. Results

Table 1 shows effect of seed rates and sowing methods on crop growth rate of three upland rice varieties at Samaru and Maigana for 2011 -2012 wet seasons and the combined. At Samaru, seed rates significantly affected crop growth rate only in 2012. Seed rate of 80kgha^{-1} recorded higher crop growth rate than 40 and 120 kg ha^{-1}. However, crop growth rate obtained with 40 kg ha^{-1} seed rate was statistically at par with that of 120 kg ha^{-1}. While at Magana in 2012 and the combined, 40 kg ha^{-1} which was statistically similar with 80 kg ha^{-1} recorded higher crop growth rate than dibbling method.

Crop growth rate significantly responded to sowing methods in both years and the combined. Result revealed that drilling which was statistically similar with broadcasting recorded higher crop growth rate than dibbling method but dibbling method was statistically similar with broadcasting method only 2011.At Maigana, sowing method significantly influenced crop growth rate only in 2012 where broadcast rice which was statistically similar with dibbled rice had higher crop growth rate than drilled rice. However, dibbled rice in turn was at par with drilled rice.

There were significant variations among the varieties of three upland rice tested on crop growth rate only in 2011 and the combined where NERICA 4 produced the highest crop growth rate, followed by NERICA 8 and the least crop growth rate was produced by JAMILA.In the combined analysis, NERICA 8 was statistically at par with JAMILA while at Maigana, NERICA 8 consistently produced the higher crop growth rate than that of NERICA 4 which was statistically similar with JAMILIA except in 2011 where NERICA 4 was similar with JAMILA and in turn was at par with NERICA 8.

Effect of seed rate and sowing method in 2011 and 2012 wet seasons and the combined on relative growth rate of upland rice varieties at Samaru and Maigana are presented in Table 1. At both locations, apart from varieties in2012wet season, all other main effects and their combined did not significantly

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affect relative growth rate. At Samaru, NERICA 4 significantly recorded higher relative growth rate which was statistically at par with NERICA 8 and in turn was at par with that of JAMILA while at Maigana, NERICA 8 significantly recorded higher relative growth rate than JAMILA which was statistically at par with NERICA 4.

Table 1: Effect of seed rates and sowing methods on Crop growth rate and Relative growth rate of three upland rice varieties at Samaru and Maigana in 2011 and 2012 wet seasons

	Samaru				Maigana				Samaru				Maigana		
Treatments	Crop growth rate				Crop growth rate				Relative growth rate				Relative growth rate		
	2011	2012	Combined		2011	2012	Combined		2011	2012	Combined		2011	2012	Combined
Seed Rates (R)															
40	3.4	4.3b	3.9		1.5	3.4a	2.4a		0.8	1.5	1.2		0.8	1.4	1.1
80	3.4	5.4a	4.4		1.6	3.1a	2.3a		3.4	1.4	1.8		0.8	1.4	1.1
120	4.5	4.1b	4.3		1.6	1.8b	1.7b		0.8	1.6	1.2		3.1	1.4	2.3
SE ±	0.40	0.15	0.22		0.11	0.15	0.08		19.36	0.11	9.7		1.48	0.13	0.74
Sowing Method (S)															
Broadcasting	3.1ab	5.1a	4.1a		1.4	3.0a	2.2		0.8	1.5	1.2		0.7	1.4	1.0
Drilling	3.8a	4.8a	4.3a		1.6	2.5b	2.1		3.4	1.5	1.8		3.3	1.5	2.4
Dibbling	2.3b	4.3b	3.3b		1.6	2.7ab	2.1		0.8	1.4	1.1		0.8	1.4	1.1
SE ±	0.40	0.15	0.22		0.11	0.15	0.08		19.36	0.11	9.66		1.48	0.13	0.74
Variety (V)															
NERICA 4	3.1a	5.1	4.1a		1.5ab	2.1b	1.8b		3.4	1.5ab	1.8		0.7	1.5a	1.1
NERICA 8	2.2b	4.4	3.3b		1.4b	3.2a	2.3a		0.8	1.7a	1.2		3.4	1.6a	2.5
JAMILA	1.5c	4.8	3.1b		1.8a	2.9a	2.4a		0.8	1.2b	1.0		0.6	1.2b	0.9
SE ±	0.20	0.31	0.19		0.11	0.11	0.08		19.35	0.11	9.68		1.48	0.09	0.74

Means followed by the same letter (s) within same column and treatment group are not statistically different at 5% level of probability using Duncan Multiple Range Test (DMRT). WAS= weeks after sowing.

Effect of seed rates and sowing methods in 2011 and 2012 wet seasons and their combined on net assimilation rate of three upland rice varieties at Samaru and Maigana are presented in Table 2. At Samaru, apart from variety, all other main effects and their combined did not significantly affect net assimilation rate. In both years, JAMMILA produced higher net assimilation rate than NERICA 4 and 8. However, NERICA 4 produced net assimilation rate that was par with NERICA 8.At Maigana, Seed rates significantly influenced net assimilation rate only in 2011. The highest net assimilation rate was recorded at 40 kg ha^{-1} seed rate, followed by 80 kg ha^{-1} while the least net assimilation rate was recorded at 120 kg ha^{-1}seed rate.

Net assimilation rate significantly responded to sowing methods in 2011 where broadcast rice recorded higher net assimilation rate than that of drilled rice which was statistically at par with dibbled rice. There was significant variation among varieties in net assimilation rate of three upland rice tested. NERICA 8 significantly recorded the highest net assimilation rate, followed by NERICA 4 while JAMILA recorded the least net assimilation rate.

Effect of seed rate and sowing method in 2011 and 2012 wet seasons and the combined on shoot dry weight of three upland rice varieties at Samaru and Maigana are presented in Tables 2.

At Samaru, Seed rates did not significantly influence shoot dry weight while Shoot dry weight significantly responded to sowing methods only in 2012 and the combined. Broadcasting method which was statistically similar drilling method significantly recorded higher shoot dry weight than dibbling but drilling in turn was similar with dibbling.

There was significant variation among the varieties in shoot dry weight of three upland rice in 2011, 2012 cropping seasons and the combined. NERICA 4 had consistently recorded the highest shoot dry weight, followed by NERICA 8 while JAMILA recorded the least shoot dry weight. At Maigana, apart from varieties that recorded significant variation in 2011, 2012 and the combined, all other main effects and their combined did not show significant effect on shoot dry weight. NERICA 8 significantly recorded the highest shoot dry weight but was statistically at par with NERICA 4 only in 2012. However, NERICA 4 in turn was statistically at par with JAMILA only in 2012 and the combined. On the other hand, JAMILA produced the least shoot dry weight only in 2012.

Effect of seed rate and sowing method in 2011 and 2012 wet seasons and the combined on days to 50% headingof the upland rice varieties at Samaru and Maigana are presented in Table 3. At Samaru in 2012 and combined, 40 kg ha^{-1} seed rate significantly delayed in days to 50% heading followed by 80 kg ha^{-1} and the earliest days to 50% heading was recorded at 120 kg ha^{-1} seed rate .However, 80 kg ha^{-1} was statistically

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at par with 120 kg ha^{-1} for the combined analysis. At Maigana in 2012 and combined, 40 kg ha^{-1} seed rate recorded more days to 50% heading than 120 kg ha^{-1} and was statistically similar with 80 kg ha^{-1} however, 80 kg ha^{-1} in turn was at par with 120 kg ha^{-1} at the combined analysis.

Days to 50% heading significantly responded to sowing methods only in the combined analysis at Samaru and in 2011 at Maigana. At both locations, result revealed that dibbled rice delayed heading which was statistically similar with drilled rice only at Samaru and the drilled rice in turn was at par with broadcast rice at both locations.

Table 2: Effect of seed rates and sowing methods on net assimilation rate and dry matter of three upland rice varieties at Samaru and Maigana in 2011 and 2012 wet seasons

	Samaru				Maigana				Samaru				Maigana		
Treatments	Net assimilation rate				Net assimilation rate				Dry Matter				Dry Matter		
	2011	2012	Combined		2011	2012	Combined		2011	2012	Combined		2011	2012	Combined
Seed Rates (R)															
40	0.02	0.04	0.02		0.07a	0.11	0.06		4.7	18.2	11.4		3.3	11.8	7.6
80	0.01	0.04	0.02		0.06b	0.10	0.05		4.7	19.3	12.0		3.2	11.0	7.1
120	0.01	0.04	0.02		005c	0.08	0.04		4.7	17.8	11.2		3.2	10.9	7.0
SE ±	0.32	0.002	0.001		0.002	0.016	0.008		0.01	1.14	0.57		0.08	0.71	0.35
Sowing Method (S)															
Broadcasting	0.02	0.04	0.02		0.07a	0.12	0.06		4.7	21.0a	12.8a		3.2	11.6	7.4
Drilling	0.01	0.04	0.02		0.05b	0.08	0.04		4.7	17.7ab	11.2ab		3.2	11.1	7.1
Dibbling	0.01	0.04	0.02		0.07a	0.09	0.05		4.7	16.6b	10.7b		3.3	11.0	7.1
SE ±	0.32	0.002	0.001		0.001	0.016	0.008		0.01	1.14	0.57		0.08	0.71	0.35
Variety (V)															
NERICA 4	0.01	0.03b	0.02b		0.06b	0.08	0.04		4.8a	25.0a	14.9a		3.3b	11.0ab	7.1b
NERICA 8	0.01	0.03b	0.02b		0.08a	0.08	0.05		4.3b	19.2b	11.7b		3.7a	12.7a	8.2a
JAMILA	0.01	0.06a	0.03a		0.05c	0.13	0.07		4.3b	11.2c	8.1c		2.8c	10.0b	6.4b
SE ±	0.22	0.002	0.001		0.001	0.017	0.008		0.01	1.08	0.54		0.09	0.62	0.32

Means followed by the same letter (s) within same column and treatment group are not statistically different at 5% level of probability using Duncan Multiple Range Test (DMRT). WAS= weeks after sowing.

There was significant variation among the varieties of the three upland rice varieties on days to 50% heading in the two years of study at both locations. In all the years at both locations, JAMILA significantly delayed in days to 50% heading, followed by NERICA 4 while NERICA 8 recorded the earliest of days to 50% heading.

Effect of seed rate and sowing method in 2011 and 2012 wet seasons and the combined on days to pphysiological maturity of three upland rice varieties at Samaru and Maigana are presented in Table 3.Seed rates significantly influenced days to physiological maturity only in 2012 and the combined in both locations.

At Samaru in 2012 and the combined, 40kgha^{-1} seed raterecorded more days to physiological maturity than 120kgha^{-1} which was statistically similar with 80kgha^{-1}.But 80kgha^{-1} seed rate in turn was at par with 120kgha^{-1} for the combined analysis. At Maigana where 40 kg ha^{-1} seed rate recorded more number of days to 50% physiological maturity, followed by 80 kg ha^{-1} while 120 kg ha^{-1} recorded the earliest days to maturity.

Sowing methods did not indicate significant effect on days to physiological maturity throughout the two years of study at both locations.

There was significant variation among the three varieties of the upland rice on days to physiological maturity in the two

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years of study in both locations. In all the years in both locations, JAMILA significantly recorded the more number of days to physiological maturity, followed by NERICA 4 while NERICA 8 recorded the least number of days to physiological maturity and was statistically similar with NERICA 4 in 2012 at Maigana.

Table 3: Effect of seed rates and sowing methods on days to 50% heading and days to 50% physiological maturity of three upland rice varieties at Samaru and Maigana in 2011 and 2012 wet seasons

	Samaru				Maigana				Samaru				Maigana		
Treatments	Days to 50% heading				Days to 50% heading				Days to 50% Maturity				Days to 50% Maturity		
	2011	2012	Combined		2011	2012	Combined		2011	2012	Combined		2011	2012	Combined
Seed Rates (R)															
40	76.9	86.8a	81.9a		77.0	84.2a	80.6a		101.6	110.2a	105.9a		101.5	107.6a	104.6a
80	76.4	83.3b	79.8b		76.7	81.9a	79.3ab		100.9	108.9a	104.8ab		99.6	103.9b	101.7b
120	77.3	81.0c	79.2b		77.1	78.9b	78.0b		100.7	107.1b	104.0b		101.3	101.7c	101.5b
SE ±	0.51	0.53	0.31		0.26	0.78	0.45		0.58	0.51	0.40		0.76	0.59	0.51
Sowing Method (S)															
Broadcasting	76.3	82.9	79.6b		76.2b	81.7	78.9		100.2	108.4	104.3		100.2	104.6	102.4
Drilling	76.6	83.7	80.2ab		76.6b	81.5	79.1		101.3	108.4	104.8		100.3	103.8	102.0
Dibbling	77.7	84.4	81.1a		78.0a	81.7	79.9		101. 6	109.4	105.5		101.9	104.8	103.4
SE ±	0.51	0.53	0.31		0.26	0.78	0.45		0.58	0.45	0.57		0.76	0.59	0.51
Variety (V)															
NERICA 4	71.3b	79.4b	75.4b		70.9b	76.0b	73.4b		96.2b	102.6b	99.4b		96.6b	97.4b	97.0b
NERICA 8	69.2c	75.7c	72.5c		68.7c	73.7c	71.2c		88.4c	100.4c	94.4c		86.6c	96.7b	91.7c
JAMILA	90.1a	95.8a	93.0a		91.2a	95.4a	93.3a		118.5a	123.2a	120.9a		119.3a	119.0a	119.2
SE ±	0.56	0.64	0.42		0.26	0.53	0.31		0.54	0..45	0.36		0.64	0.57	0.43

Means followed by the same letter (s) within same column and treatment group are not statistically different at 5% level of probability using Duncan Multiple Range Test (DMRT). WAS= weeks after sowing.

4. Discussion

The higher CGR obtained was due absorbed sun radiation with increase in leaf area which also increased dry matter accumulation . The CGR after reaching the maximum rate, decreased. This was in case of leaves that grow old and shedding as a result of dry matter decreases due to leaves shedding. [4] got similar results.The ability of leaves in sun absorption and high material transportation in NERICA varieties was responsible for the differences observed in NAR. Also RGR deceases in growth season length with increase of plant age in rate of structure texture to metabolic tissue which decreased and shadow of upward leaves to lower leaves restricted appropriate usage from sources. [17]reported that LAI and total dry matter were related to each other and the high LAI in the flowering stage is necessary for high yielding.

The earlier heading and maturity recorded at higher seed rates at Samaru and Maigana in 2012 and the combined was however expected since increasing numbers of seed rates would result in high competition for scarce resources thereby resulting in stress. The stress imposed in turn led to early heading and maturity. At low plant population and especially with adequate growth resources, vegetative growth would be prolonged thereby leading to delay in maturity.

The reverse was the case at high seed rate due to intense competition for scarce resources which might be exhausted within a short period that consequently led to early heading and maturity.

The non-significant differences in sowing methods on the net assimilation rate, relative growth rate and shoot dry weight in the two years of this study was because the three sowing methods promoted rapid and vigorous growth of the crops which enable them to utilize the available resources. On the other hand, the higher shoot dry weight recorded by broadcasting than other methods was due to uneven distribution of seeds on the plots which may have enable crops sown by broadcasting methods to trap more sunlight for photosynthesis which led accumulation of more dry matter.

The early heading reached by crops sown using broadcasting methods was because of shallow root establishment with higher intra competition due uneven spacing between the plants per unit area which triggered quicker reproductive phase responses. Dibbling and drilling methods significantly delayed days to 50% heading which definitely prolonged maturity period.Similar observation was made by [18] who reported that growth dyanmics and partitioning patterns of rice depend on cultural practices particularly sowing methods. Though all the varieties used were early maturing varieties, the maturity periods greatly depends on the genotype and

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cultural practices. Therefore, the varietal growth and development responses to different sowing methods should be considered when selecting the most appropriate sowing methods.

The variation in growth and development among the three rice varieties could be attributed to the genetic characteristics and environmental factors such as temperature, photoperiods and light intensity, soil factors and cultural manipulation such as plant density, planting methods and moisture supply [19]. The similarity in the genetic make-up of the varieties displayed at both locations was an indication that less robust varieties were able to make equal utilization of the environmental resources as other varieties hence lack of variation in RGR and NAR. This is in agreement with [12] who reported that varieties exhibit high similarity in terms of response to input levels and the overall effect expressed depend mainly on interaction with the environment. The significant variation among the varieties in terms of time taken to reach fifty percent heading and physiological maturity was mainly genetic and other resources such climatic and nutrition which prolonged the vegetative period. Under optimum growing conditions the number of days to 50% heading of rice crop can alternatively be used to estimate the number of days to attain maturity. The early heading and maturity of NERICA 4 and 8 in the two seasons at both locations is an indication that the two varieties are early maturing. This character was confirmed by [20] who described NERICA varieties as early maturing. The significant variation in days to maturity of two NERICA varieties and JAMILIA indicated that the varieties used in these experiments did not belong to the same maturity group. Maturity of rice varieties can be classified as very early (less than 105 days), early (105-120), medium (121-135days, late (136-160days) and very late (over 160 days) [21]. Unlike ripening phase, which takes 35days after 50% heading to reach maturity, the vegetative phase, irrespective of the variety is the only growing phase that varies to give differences in maturity periods among rice genotypes [21]. Hence, the varieties tested except JAMILA were classified as very early maturing. The delay in Maturity of JAMILIA variety could be due to their robust vegetative growth resulting from the efficient utilization of resource which caused increase in the assimilatory leaf area thereby increasing dry matter production and allocation to vegetative parts hence delaying maturity period. Shah [22] reported that some varieties were more efficient in transfer of photosynthate to economic sink.

5. Conclusion

Based on the result obtained from the study, it can be inferred that JAMILA matured later and had higher physiological indices in Samaru while NERICA 8 perform better in Maigana. Consequently broadcasted or drilled rice performed better at 40 kg ha^{-1} seed rate**.**

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