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Response of Some Physiological Traits of Hungry Rice (*Digitaria exilis* Kippis Stapf) to Sowing Methods and Nitrogen Rates at Badeggi, Nigeria

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Abstract

Field experiments were conducted at Badeggi (Lat. 9°45'N and Long. 6°07'E) in the rainy seasons of 2016 and 2017 to evaluate the response of some physiological traits of hungry rice (D. exilis) to sowing methods and nitrogen rates. The treatments consisted of two sowing methods (broadcasting and drilling at 30 cm inter-row spacing) and three nitrogen rates (0, 30 and 60 kg N). The experiment was laid out in a randomized complete block design with three replications. The results obtained showed that plant dry matter was significantly higher in the drilling method of sowing at 6 and 12 weeks after sowing (WAS) and the lowest plant dry matter was recorded in broadcasting in both years of studies. While nitrogen at all rates showed no significant influence on plant dry matter at 6 WAS also in both years of studies. While at 12 WAS in both years of investigation, nitrogen applied at 60 kg N ha^{-1} produced significantly higher plant dry matter in both years. Significantly higher crop growth rate (CGR) at 6 and 12 WAS was recorded in drilling method of sowing and lowest was obtained in broadcasting method of sowing in both years. Nitrogen showed no significant influence on CGR in both sampling years. Relative growth rate (RGR) was significantly higher in broadcasting method of sowing and the lowest was recorded in the drilling method at 6 and 12 WAS in 2016 and 2017 respectively. Significantly higher grain yield was produced in drilling method of sowing and nitrogen at the rate of 30 kg N ha^{-1}, while the lowest grain yield was obtained in the broadcasting method when nitrogen was not applied.

Keywords: hungry rice, plant dry matter, crop growth rate, relative growth rate, sowing methods

Abbreviations: WAS: weeks after sowing; CGR: crop growth rate; RGR: relative growth rate

Introduction

Hungry rice (*D. exilis*) is most nutritious crop among all the cereals used as food, animal feed and for industrial purposes. The crop has fast growing recognition in the world's cereal production and is a staple for about one third of the world's population. In hungry rice (*D. exilis*) producing states in Nigeria, it contributes about 10 to 15% as staple, 5% to the value added in agriculture and 3% good agricultural practice (GAP). To feed the ever-increasing population of a country like Nigeria, the need for more hungry rice (*D. exilis*) will continue and there is high possibilities to increase hungry rice (*D. exilis*) production in Nigeria through the development of new high yielding varieties and adoption of proper packages technologies. The concern has been that yield plateau in hungry rice (*D. exilis*) has not been reached as in other major crop species such as maize (*Zea mays* L.), rice (*Oryza sativa* L.), Sorghum (*Sorghum bicolor*), wheat (*Triticum aestivum* L.) amongst others.

For food production per hectare to be reached, improved management systems and cultivators that can respond to our cultural practices must be developed. The continuous agronomic practices of the new germsplasm materials as donors of various genes of agronomic importance is a vital pre-requisite for further improvement of hungry rice (*D. exilis*) accessions. Sowing methods, fertilizer application and seed rates are some of the major factors that determine the ability of crops to capture resources. It will be of particular importance that it will be under fairly close control by farmers in hungry rice (*D. exilis*) producing areas. The definition of the relationship between such factors will establish optimum attainable yields under various situations [1]. There is no uniform recommendation by agronomists regarding sowing methods, fertilizer and seed rates per unit area. Yield may be increased most effectively for each input or crop production practices are considered in terms of how they will affect accessions in the Guinea Savanna Zone of Nigeria by broadcasting and drilling methods of sowing, no use of fertilizers and the use of different seeding rates. Therefore, it became imperative to investigate the effect of sowing methods, nitrogen and seed rates on some physiological traits of hungry rice (*D. exilis*).

Materials and Methods

The trials were carried out on the research field of the National Cereals Research Institute, Badeggi during the raining seasons of 2016 and 2017. The design of the experiment was a randomized complete block design with three replications. One hungry rice (*D. exilis*), Namuruk accession was used as the test crop. The treatments consisted of two sowing methods (broadcasting and drilling at 30 cm inter-row spacing) and three nitrogen rates (0, 30 and 60 kg N ha^{-1}). Plot size was 3.0 m × 4.0 m. Phosphorus as P_20_5 at 30 kg ha^{-1} was applied at the time of sowing and was thoroughly incorporated into the soil by hoeing. Nitrogen (in form of urea) rates at 30 and 60 kg N ha^{-1} was applied in two split doses. Half dose of each rate was applied at 4 WAS and the second half was applied at 8 WAS respectively. Five plants were randomly selected and cut using a knife at 6 WAS (maximum vegetative stage) and at 12 WAS at milking stage in each plot to determine plant dry matter. The plants were sun-dried for 10 days and were placed in an oven at 70°C for 72 h to a constant weight and value weighed. CGR was calculated as dry matter difference of two consecutive samples divided by their interval for a particular ground area. CGR represents dry weight gain by a unit area of a crop in a unit time expressed as gm day^{-1} m^2. The formula used by Yaduraju et al. was used to record the CGR [2].

$$CGR = \frac{W_2 - W_1}{T_2 - T_1}$$

where, W_2 is the final dry weight at milking state (11th September 2016 and 2017)

W_1 is the previous dry weight at vegetative stage (15th August 2016 and 2017)

T_2 is time when final weights of plants at milking stage (11th September 2016 and 2017)

T_1 is time when previous weight of plants were recorded (15th August 2016 and 2017)

RGR was calculated after the destruction of the plant samples that have been oven-dried at 70°C for 24 h. The RGR was computed using the formula by Blackman [3].

$$RGR = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1} \text{ g/g/week}$$

where, W_2 is the dry matter weight at a sampling period

W_1 is the dry matter weight at the next sampling period

T_2 is the time at which W_1 was taken

T_1 is the time at which W_2 was taken

Results and Discussion

Effect of sowing methods and nitrogen rates on plant dry matter

The effect of sowing methods and nitrogen rates on plant dry matter is presented (Table 1). The results indicated that sowing methods had a significant influence on plant dry matter at 6 and 12 WAS in both years of studies. It was observed that at 6 and 12 WAS, significantly higher plant dry matter was recorded in the drilling method of sowing and the lowest plant dry matter was obtained in the broadcasting method. The highest plant dry matter obtained in the drilling method of sowing could be attributed to higher plant density and higher concentration of nutrients. While the lower plants dry matter in broadcasting method of sowing could be due to sparse plant population, competition for scarcely available nutrients between crops and weeds. This finding is in corroboration with Ghulam who reported significantly higher plant dry matter in drilling method of sowing and the lowest plant dry matter in broadcasting method [4]. Nitrogen at all rates was observed to show no significant effect on plant dry matter at 6 WAS. This could be due to sufficient residual nitrogen in soil the applied nitrogen could not significantly affect plant dry matter or it might have been at the period of leaf extension and dry matter accumulation follow carbon movement and the role of urea was negligible. But nitrogen at higher rate (60 kg N ha^{-1}) had significant effect on plant dry matter at 12 WAS. It could be that nitrogen applied at higher rate encouraged the growth and development of the vegetative parts of the crop which eventually resulted in higher dry matter accumulation. The result is in line with Ebrahim et al. who reported that maximum dry matter accumulation at higher nitrogen rate than at lower rates [5]. Also, Shibu et al. reported that increased nitrogen rates result in an increase in plant dry matter [6].

Treatment	**6 WAS**		**12 WAS**	
	2016	**2017**	**2016**	**2017**
Sowing method				
Broadcasting	3.21b	29.65b	33.86	47.72b
Drilling	4.08a	33.31a	34.30a	50.70a
SE+	0.881	0.464	0.802	0.863
Nitrogen rate (Kg N ha^{-1})				
0	3.63	31.03	33.41b	48.85ab
30	3.61	32.12	33.55b	47.26b
60	2.70	31.30	35.27a	50.75a
SE+	0.092	1.471	0.936	1.052

Table 1: Influence of sowing methods and nitrogen rates on plant dry matter at 6 and 12 weeks after sowing (WAS). Means in a row of treatments followed by the same letter(s) are not significantly different at ($P < 0.05$) level of probability using Duncan's Multiple Range Test (DMRT).

Effects of sowing methods and nitrogen rates on crop growth rate

Sowing method showed a significant effect on CGR of hungry rice (*D. exilis*). Significantly, higher CGR was recorded in the drilling method of sowing and the lowest CGR was produced in the broadcasting method at 6 and 12 WAS in 2015. This could be attributed to the fact that the drilling method of sowing tends to improve physiological growth indices of crops. The results obtained are in line with Ghulam who reported significantly higher CGR, leaf area, dry matter and grain weight yield among other physiological growth indices in wheat (*Triticum aestivum* L.) [4]. Nitrogen at all rates was observed to show no significant effect on CGR at 6 and 12 WAS in both years of studies. This scenario could be due to the fact that at early stages of crop growth, the leaves are not well developed, so less dry matter was produced. While at 12 WAS, the dry matter produced was not significant because of senescence and abscission of the leaves whereby active photosynthetic tissues were reduced and structural tissues were increased. A similar finding has been reported by Azarpour et al. [7] (Table 2).

Treatment	**6 WAS**		**12 WAS**	
	2016	**2017**	**2016**	**2017**
Sowing method				
Broadcasting	0.39b	0.28	0.49b	0.46
Drilling	0.65a	0.30	0.69a	0.37
SE+	0.020	0.027	0.026	0.03
Nitrogen rate (Kg N ha^{-1})				
0	0.53	0.26	0.61	0.44
30	0.49	0.27	0.57	0.36
60	0.55	0.34	0.60	0.43
SE+	0.024	0.043	0.029	0.03

Table 2: Influence of sowing methods and nitrogen rates on crop growth rate (CGR) at 6 and 12 weeks after sowing (WAS). Means in a row of treatments followed by the same letter(s) are not significantly different at ($P < 0.05$) level of probability using Duncan's Multiple Range Test (DMRT).

Effect of sowing methods and nitrogen rates on relative growth rate

RGR which is a measure of the increase in dry matter with a given amount of assimilatory material at a given point of time significantly high RGR was recorded in the broadcasting method of sowing than in drilling method at 6 WAS in 2015 and the lowest RGR was obtained in drilling method. This might be as a result of the effect of variation usually exhibited by sowing methods on all growth and yield parameters of the crop. Similar findings have been reported in wheat (*Triticum aestivum* L.) [8]. While in 2016 at 12 WAS, significantly higher RGR was produced in the drilling method of sowing and the lowest was obtained in the broadcasting method. The superiority of drilling method of sowing over broadcasting method in terms of RGR could be due to high plant density, less competition for higher concentration of available nutrients in the drilling method of sowing. A similar finding has been reported by Umed et al. [9] (Table 3). RGR was observed to be significantly higher when nitrogen was not applied at 6 WAS in 2015. This could be due to sufficient residual nitrogen in the soil that was sufficient for increase in RGR. This result is contrary to the findings reported by Sharifai who reported an increase in RGR at higher nitrogen rates in maize (*Zea mays* L.) [10]. While at 12 WAS, nitrogen rates showed no significant effect on RGR in both years of experimentation. This might be attributed to senescence and reductive function of photosynthetic tissues and an increase in structural tissues. Singh et al. reported similar results on RGR changes under nitrogen fertilization in *Brassica campestris* (var.) [11].

Effects of sowing methods and nitrogen rates on grain yield (Kg ha^{-1})

Sowing methods showed significant influence in grain yield of hungry rice (*D. exilis*). The highest grain yields of 303.10 and 404.88 kg ha^{-1} were recorded in drilling method of sowing while the lowest yields of 224.21 and 282.14 kg ha^{-1} were produced in the broadcasting method. Similar findings have been reported by Chang et al. [12] (Table 4). Nitrogen at all rates showed a significant effect on grain yield of hungry rice (*D. exilis*) in both years. And significantly highest grain yield was recorded when 30 kg N ha^{-1} was applied and the lowest grain yield was obtained at when nitrogen was not applied.

These findings also corroborate with Ebrahim et al. who reported an increase in nitrogen fertilizer rate at 30 kg ha^{-1} caused a significant increase in grain yield [5].

Inclusion, these results indicated that proper sowing method through drilling and application of 30 kg ha^{-1} of inorganic nitrogen fertilizer led to less competition of weeds and thereby, increased grain yield of hungry rice greater than in broadcasting and at application of nitrogen inorganic fertilizer at 60 kg ha^{-1}. This could be as a result of enough nutrients needed by the hungry rice was supplied by the application at 30 kg ha^{-1} nitrogen fertilizer, and coupled with proper light penetration for photosynthesis, good soil environment for uptake of soil nutrients and water use efficiency as the population through drilling the method was lesser than broadcasting.

Treatment	**6 WAS**		**12 WAS**	
	2016	**2017**	**2016**	**2017**
Sowing method				
Broadcasting	0.64a	0.40	0.81	0.96a
Drilling	0.49b	0.41	0.83	0.07b
SE+	0.029	0.01	0.036	0.016
Nitrogen rate (Kg N ha^{-1})				
0	0.66a	0.42	0.50	0.46
30	0.48b	0.40	0.52	0.40
60	0.55ab	0.41	0.56	0.44
SE+	0.053	0.01	0.038	0.020

Table 3: Influence of sowing methods and nitrogen rates on the relative growth rate (RGR) at 6 and 12 weeks after sowing (WAS). Means in a row of treatments followed by same letter(s) are not significantly different at ($P < 0.05$) level of probability using Duncan's Multiple Range Test (DMRT).

	2016	**2017**
Sowing method		
Broadcasting	224.21b	282.14b
Drilling	303.10a	404.88a
SE+	11.697	10.549
Nitrogen rates (Kg N ha^{-1})		
0	195.55b	267.13c
30	375.56a	493.11a
60	218.33b	370.31b
SE+	20.780	17.313

Table 4: Influence of sowing methods and nitrogen rates on grain yield (Kg N ha^{-1}). Means in a row of treatments followed by the same letter(s) are not significantly different at ($P < 0.05$) level of probability using Duncan's Multiple Range Test (DMRT).

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