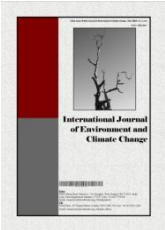

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Response of Date of Sowing and Varieties on Growth and Yield of Niger under Eastern Ghat High Land Zone of Odisha

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out under All India Coordinated Research Project on Niger at Regional Research and Technology Transfer Station (OUAT), Semiliguda of Koraput district under Eastern Ghat High Land zone of Odisha in acidic soil during three consecutive *kharif* seasons from 2015 to 2017 to study the response of date of sowing and varieties on growth and yield of niger. The experiment consists of six dates of sowing with 15 days interval *viz*. 15th July, 30th July, 14th August, 29th August, 13th September and 28th September with two varieties of niger namely Deomali and Utkal Niger-150. The experiment was performed in split plot design with three replications. The pooled data for three years revealed that out of six different dates of sowing, the

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crop which was sown on 15th July resulted significantly the highest seed yield (563 kg ha^{-1}) with a net monetary return (Rs. 8083 ha^{-1}) and benefit cost ratio (1.6). Niger variety Utkal Niger-150 recorded higher seed yield and economic returns. It was discovered that the environment had a greater impact on variety yield levels than the varieties themselves. Less dry spells, no wet spells, a high number of sunshine hours and a moderate temperature were all essential environmental factors.

Keywords: Rainfall; agroclimatic situation; oilseed crop; capitula; economics.

1. INTRODUCTION

Niger (*Guizotia abyssinica* (L.f.) Cass.) is one of the most important minor oilseed crop. It is grown on about 2.99 lakh hectares in India, with a production of 0.98 lakh tonnes and a productivity of 327 kilogrammes per hectare. It occupies 0.65 lakh hectares in Odisha, with a production of 0.23 lakh tonnes and a productivity of 360 kg ha^{-1} [1]. The rainfall of the Eastern Ghat High Land zone of Odisha is very erratic and varies temporally and spatially. 75-80% of the total rainfall is received during the monsoon season only. The production and productivity of upland paddy is subjected to the drought like situation and thus poor yield. The upland area under paddy is 21,000 ha. To get a sustainable yield from this upland area, niger is found to be a good substitute due to its low water requirement and drought resistance capacity. Economic yield of crop may be limited by source (photosynthesizing organs) or sink (storage organs) or the capacity to translocate assimilates from one part to other limiting processes such as water or nutrient uptake or transport. Because source and sink are developed simultaneously in crops like niger, modifications to two components can be made quickly. When it comes to deciding whether a source or a drain is more limiting, the seasonal sequence of conditions is crucial. The establishment of a good stand is a must in order to get high yields. It is dependent on sowing time, depth and manner. Sowing early in the season may not be beneficial; for example, sowing rainfed niger in June may result in crop failure if a lengthy dry period occurs between the second of June and second weeks of July. However, sowing early in certain situation increases the yield. In other words, delayed sowing invariably reduces yield. Rainfed crop yields are reduced due to delay in sowing beyond June. The reduction in yields is attributed to early induction of flowering, unfavourable temperature and erratic rainfall. Most of the tropical crops are short day plants. Day length starts falling from July onwards, but the reduction in day length is steep from October onwards. Due to a favourable environment at all phases of the crop growth, sowing the crop at the optimal time boost the yield. After adequate vegetative development, flowering is induced. During critical times, moisture stress or dry spells can be avoided. Due to varied distribution pattern of rainfall, it is pertinent to know the exact sowing window of the crop for optimum yield. Good quality seed is a prime importance in agriculture. They should germinate rapidly and uniformly when sown with high yield potential. Emergence should be prompt and early vegetative growth should be vigorous and suitable for the particular agroclimatic situation. Farmers often demand the new varieties for their farming situation. Considering this, the varieties are also to be screened to test its suitability in this agroclimatic zone. The exact date of sowing and the suitable variety plays an important role in sustainable production. The potential yield of cultivars within its genetic limit is set by its environment, and the genotype of niger plays an essential part in determining the yield of a crop. The introduction of new niger cultivars has resulted in a significant increase in productivity per unit area. These cultivars' yields can be boosted even further by creating the ideal environment through agronomic methods. The yield potential of different varieties is determined by a variety of physiological processes that are influenced by both genetics and the environment. Sowing time impacts plant height, number of branches, blooming, and capitula bearing behaviours, as well as the time available for vegetative growth before the commencement of flowering, which is mostly determined by photoperiod [2]. Among cultivation practices, sowing time is an important parameter which affects the growth, development and yield of crop to a great extent. With the right agronomic approaches and genotypes, the niger's production potential can be completely realised. Sowing at the right time is one of the most critical methods for maximising a variety's genetic potential since it gives the best growing circumstances in terms of temperature, light, humidity, and rainfall. The growth phase of the crop should synchronize with optimum

environmental conditions for better expression of growth, yield and its ancillary characters The survey-based study indicates that the replacement of age-old crop varieties along with adjustment of sowing time in the crop sequence may help to improve the yield level as well as to expand the areas in potential regions. This could be attributed to overall improvement in plant vigour leading to better manifestation of yield attributes in niger. In niger, though research information on these aspects are available and very meager, so still a few more technical information are to be found out. Therefore, the present investigation was carried out to study the response of date of sowing and the varieties on growth and yield of niger.

2. MATERIALS AND METHODS

2.1 Experimental Site

To achieve the objectives, a field experiment was conducted under All India Coordinated Research Project (AICRP) on Niger at Regional Research and Technology Transfer Station (OUAT), Semiliguda under Koraput district in Eastern Ghat High Land zone of Odisha during three consecutive *kharif* seasons of 2015, 2016 and 2017. The farm is located in the geographical parallels of $18^0$42'N latitude, $82^0$30'E longitude and an altitude of 884.0 m. The region is marked by its warm and humid climate with an average annual rainfall of 1500 mm, most of which is received from middle of June to middle of October.

2.2 Soil Characteristics

The soil samples collected from field were air dried, grounded with mortar pestle and sieved in 2 mm sized mesh [3]. The soil of experimental site was red, sandy to clay loam in texture and acidic in reaction (pH 5.8) with low in available N (170 kg ha^{-1}), medium in available P (16 kg ha^{-1}) and available K (145 kg ha^{-1}).

2.3 Experimental Design

The experiment consists of six dates of sowing with 15 days interval *viz*. 15th July, 30th July, 14th Aug, 29th Aug, 13th Sept and 28th Sept with two varieties of niger namely Deomali and Utkal Niger-150 (Table 1). The experiment was evaluated in split plot design with three replications for statistical analysis. The niger crop was sown with seed rate of 10 kg ha^{-1} with a row spacing of 30 cm. The plant to plant spacing of 10 cm was maintained by thinning operation. The thinning and weeding operations were carried out on 15 and 21 days after sowing in every year under the experimentation. The recommended dose of fertilizer (40:40:20 NPK kg ha^{-1}) was applied to the crop. Full dose of P, K and half N in form of Diammonium Phosphate (DAP), Muriate of Potash (MOP) and Urea were applied as basal and rest half N was applied after three weeks after sowing. The crop was harvested at physiological maturity. The periodical biometric and post harvest observations were taken at regular interval.

The weather data (Table 1 to 4) presented in Fig. 1 to 5 showed that the rainfall received during crop period was 806.9 mm during 2015. Maximum temperature (Tmax) varied from 27.7 to 29.4ºC and minimum temperature (Tmin) varied from 4.9 to 17.2℃. The total sunshine hour received during the crop season was 880.5 hours. The maximum relative humidity varied from 85.3% to 95.3%. The weather data (Table 3) showed that the rainfall received during crop period was 1083.3 mm during 2016. The Tmax varied from 26.6 C to 28.1°C and Tmin varied from 5.9 to 14.4°C. The total sunshine hours received during the crop season was 115.4 hours. The maximum relative humidity varied from 95.6% to 96.9%. The weather data (Table 4) showed that the rainfall received during crop period was 1166.8 mm during 2017. The Tmax varied from 26.2 C to 28.6ºC and Tmin varied from 11.1 to 20.8ºC. The total Sunshine hour received during the crop season is 834.4 hours. The maximum relative humidity varied from 70.6% to 99.5%.

2.4 Statistical Analysis

The experimental data collected during the crop growth and harvest were analysed statistically following the procedure as described by Gomez and Gomez [4]. Treatment differences were tested at 5% level of significance by F test and using analysis of variance (ANOVA) for making comparison among treatment means for various yield and yield components of niger.

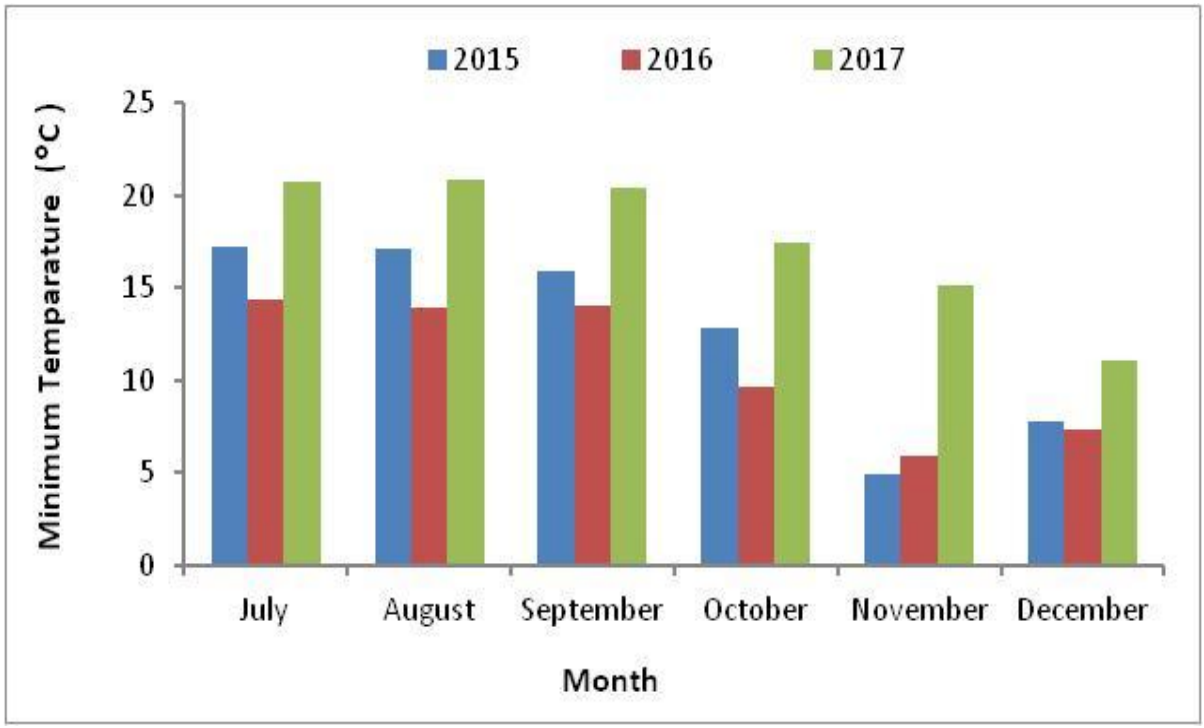

Fig. 1. Monthly minimum temperature (°C) during niger growing periods of three consecutive years 2015-17

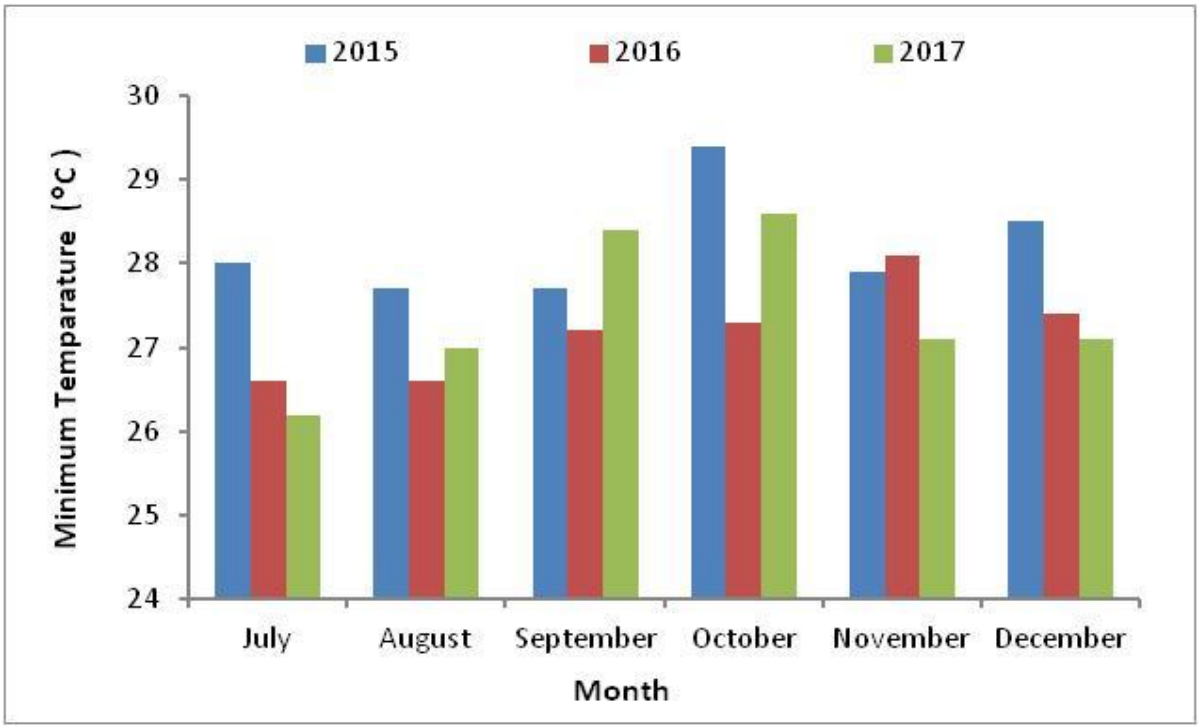

Fig. 2. Monthly maximum temperature (°C) during niger growing periods of three consecutive years 2015-17

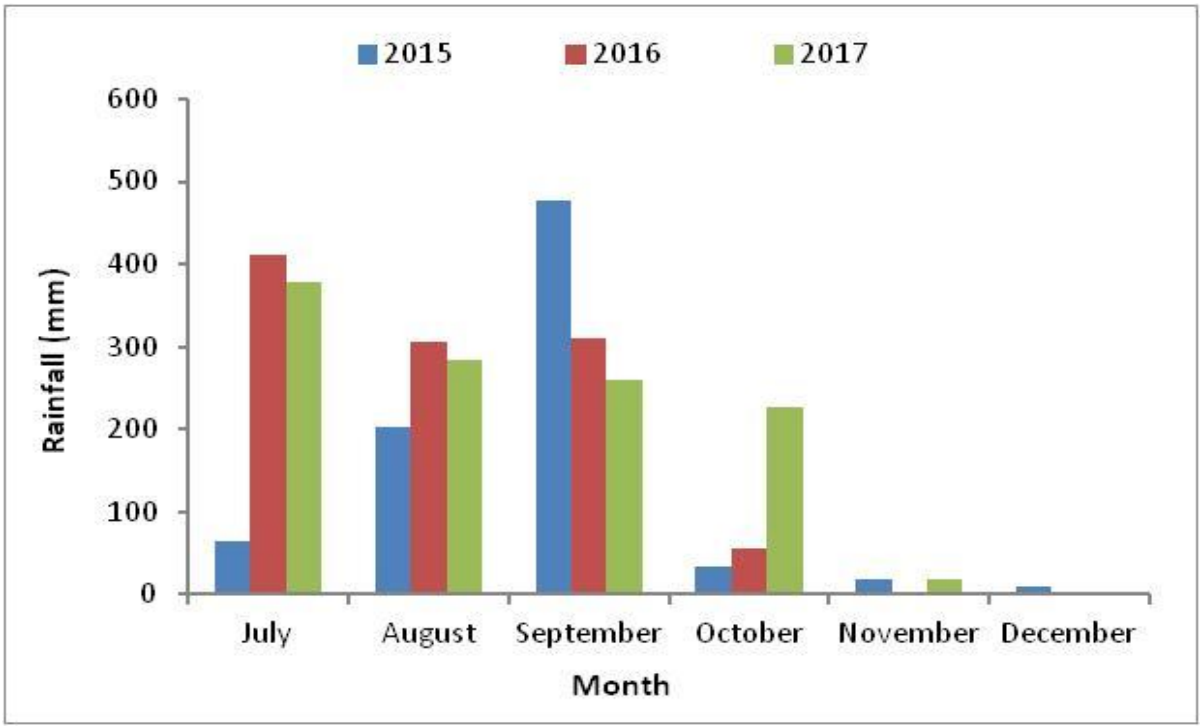

Fig. 3. Monthly rainfall (mm) during niger growing periods of three consecutive years 2015-17

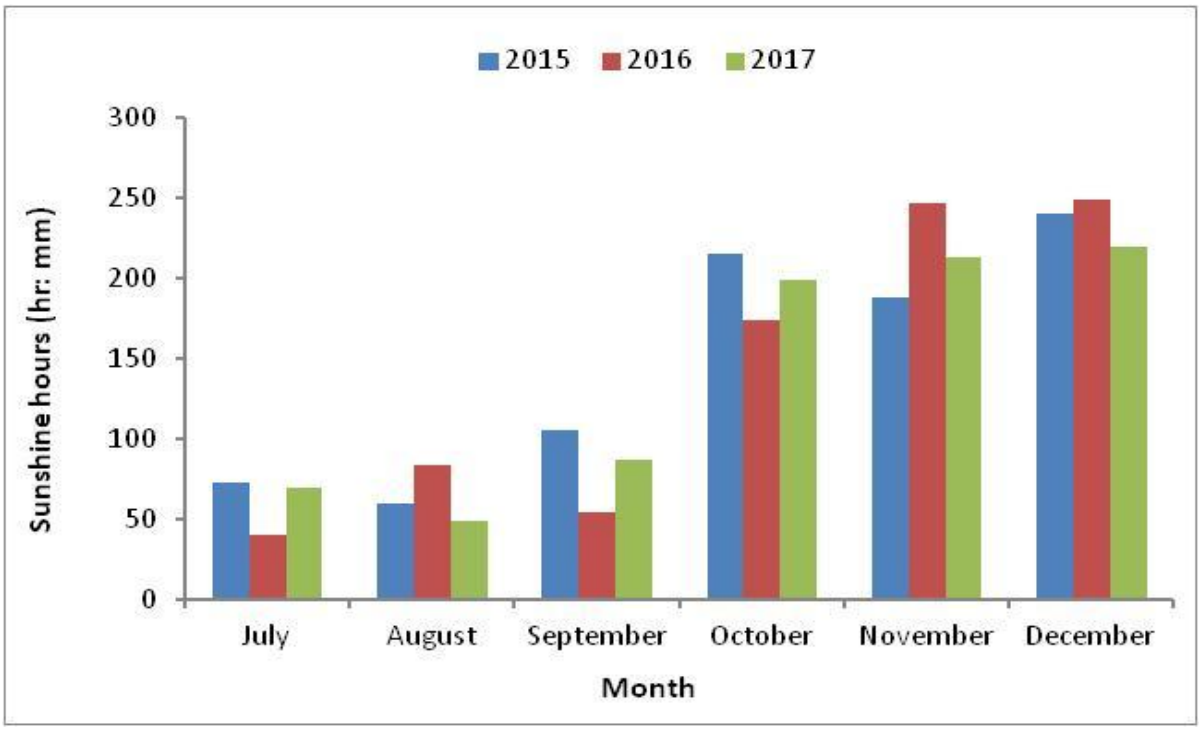

Fig. 4. Monthly sunshine hours (hr: mm) during niger growing periods of three consecutive years 2015-17

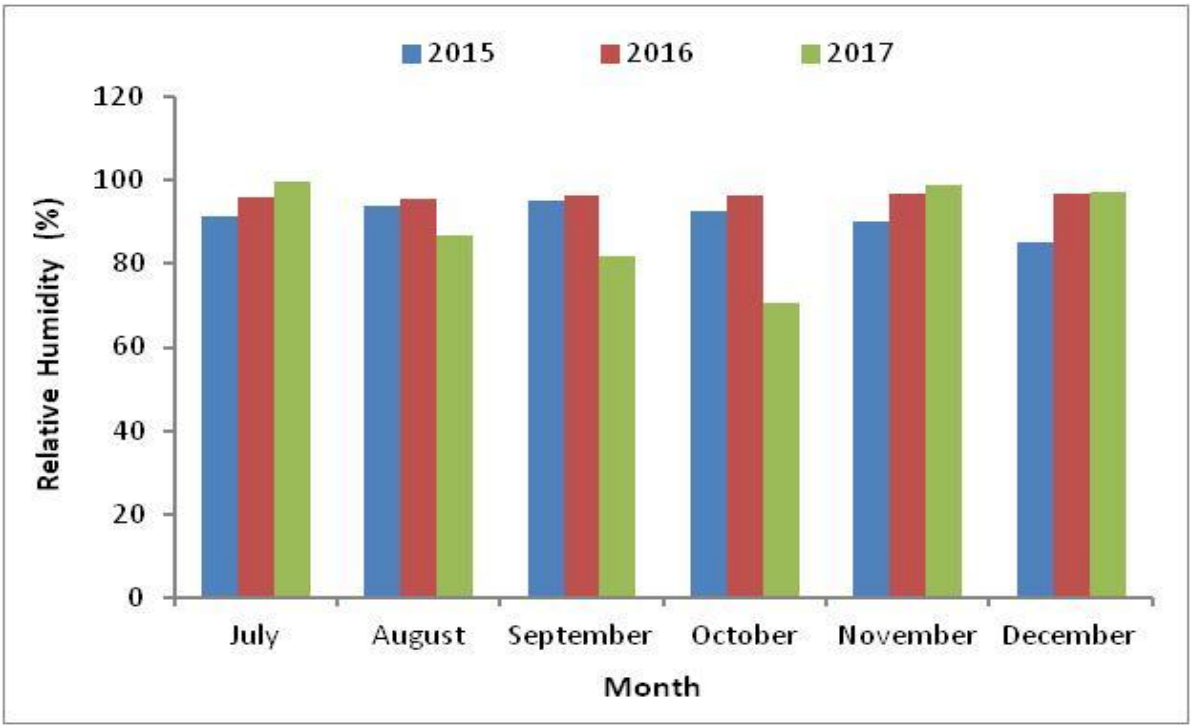

Fig. 5. Monthly relative humidity (%) during niger growing periods of three consecutive years 2015-17

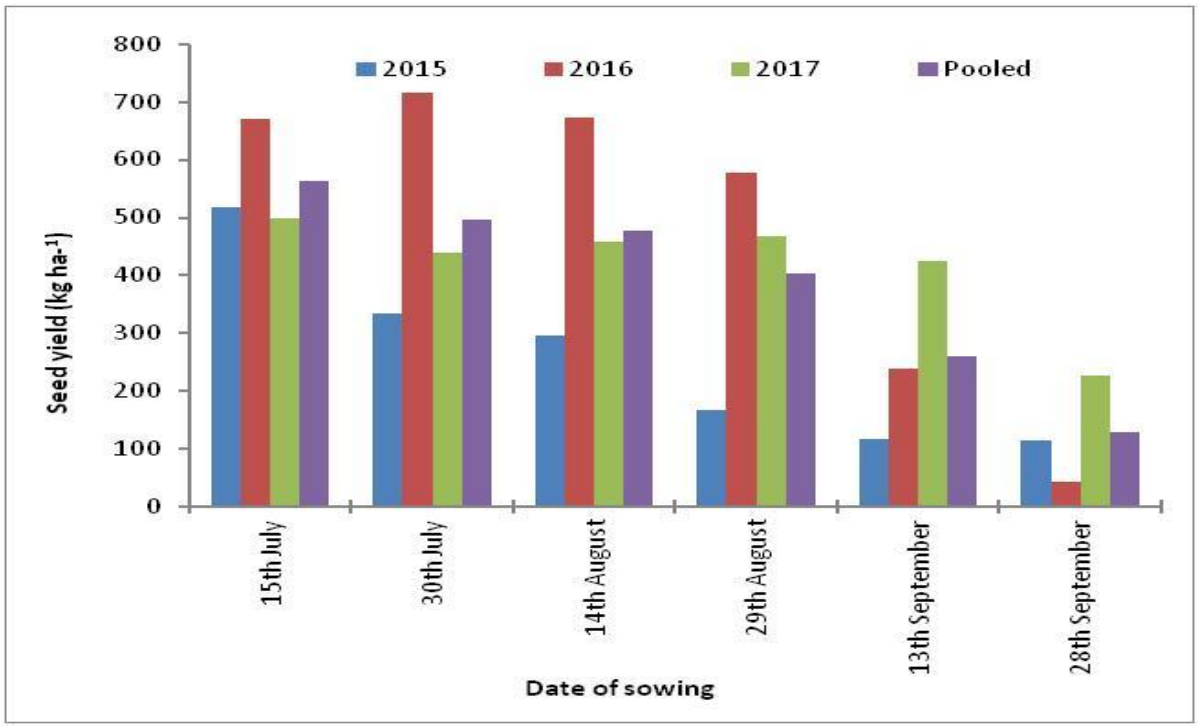

Fig. 6. Influence of date of sowing, variety and their interaction effect on seed yield of niger

Table 1. Rainfall (mm) and dry spell (days) of the experimental station during the crop growth period

Month	Rainfall (mm)			Normal rainfall (mm)	Dry spell (days)		
	2015	2016	2017		2015	2016	2017
July	64.3	410.7	378.7	375.6	21	10	10
August	202.6	305.0	284.5	393.6	18	14	15
September	477.8	310.1	259.6	256.3	19	11	16
October	33.2	55.2	266.0	126.1	30	25	19
November	18.8	3.0	18.0	32.6	30	29	28
December	10.2	0.0	0.0	6.5	30	31	31

Table 2. Meteorological information of Semiliguda centre during crop growth period in 2015

Month	Tmin	Tmax	Rainfall (mm)	Sunshine hours (hr:mm)	Relative Humidity (%)
July	17.2	28.0	64.3	73.0	91.2
August	17.1	27.7	202.6	59.5	94.0
September	15.9	27.7	477.8	105.3	95.3
October	12.8	29.4	33.2	214.4	92.5
November	4.9	27.9	18.8	187.9	90.2
December	7.8	28.5	10.2	240.4	85.3

Note: Tmin= Minimum temperature; Tmax= Maximum temperature; hr= Hour

Table 3. Meteorological information of Semiliguda centre during crop growth period in 2016

Month	Tmin	Tmax	Rainfall (mm)	Sunshine duration (hr:mm)	Relative Humidity (%)
July	14.4	26.6	410.7	40.1	96.1
August	13.9	26.6	305.0	83.5	95.6
September	14.0	27.2	310.1	54.1	96.2
October	9.7	27.3	55.2	173.4	96.4
November	5.9	28.1	3.0	246.0	96.9
December	7.4	27.4	0.0	248.4	96.7

Note: Tmin= Minimum temperature; Tmax= Maximum temperature; hr= Hour

Table 4. Meteorological information of Semiliguda centre during crop growth period in 2017

Month	Tmin	Tmax	Rainfall (mm)	Sunshine duration (hr:mm)	Relative Humidity (%)
July	20.7	26.2	378.7	69.0	99.5
August	20.8	27.0	284.5	48.5	86.9
September	20.4	28.4	259.6	86.7	81.9
October	17.5	28.6	226.0	198.4	70.6
November	15.1	27.1	18.0	212.4	98.8
December	11.1	27.1	0.0	219.4	97.4

Note: Tmin= Minimum temperature; Tmax= Maximum temperature; hr= Hour

3. RESULTS AND DISCUSSION

3.1 Effect on Growth Parameters

The 15th July sown crop resulted significantly taller plants (225.7 cm) with maximum number of branches plant^{-1} (7.8) at harvest. Shorter plant height (68.0 cm) with minimum number of branches plant^{-1} (4.5) were recorded by the last sown crop on 28th September among various dates of sowing. Maximum plant height under 15th July sowing might be assigned due to the reason that the crop did not experience moisture stress at critical stages. The crop was exposed to favourable temperatures and high relative humidity. Delay in sowing times up to 28th September significantly reduces the plant height and number of branches plant^{-1} in niger. Similar results were also reported by Agarwal et al. [5]; Jagtap et al. [6]; Nayak and Paikaray [7]; Paul et al. [8]; Mili et al. [9]. In case of varieties, Deomali recorded significantly taller plants (157.8 cm) which is 5.95% higher than Utkal Niger-150 (148.4 cm). This may be due to the genetic constituent of variety Deomali. Similar variability in growth parameters among the varieties was also reported by Mishra et al. [10] and Mohan Kumar et al. [11] in niger crop. The interaction effect of date of sowing x variety was found to be non-significant. It indicates that the joint effect of date of sowing and variety is not statistically higher than the sum of both effects individually.

3.2 Days to 50% Flowering and Maturity

Pooled data of 3 years (Table 5) showed a decreasing trend in days to 50% flowering and days to maturity with delay in date of sowing from 15th July to 28th September with an exception of 13th September (50% flowering). Maximum days to 50% flowering and days to maturity were recorded with date of sowing on 15th July (73 and 127 respectively). Minimum days to 50% flowering (42) and days to maturity (90) were recorded on 13th and 28th September respectively. This result was in conformity with the findings of Jagtap et al. [6]. The variation in growth parameters viz., earliness in flowering and maturity among the date of sowing might be due to the influence of environmental factors such as stress or less rainfall condition, temperature, sunshine, rainfall and relative humidity in late sown condition of the crop. In regards to varieties, both the varieties were significantly different with each other. Days to 50% flowering and days to maturity were significantly higher with respect to variety Deomali (55 and 108) as compared to Utkal Niger-150 (54 and 106).

3.3 Effect on Yield Attributes

Pooled data of 3 years (Table 5) revealed that the number of capitula plant^{-1} and number of seeds capitula^{-1} varied significantly with different dates of sowing. Both these yield attributes showed a decreasing trend with delay in date of sowing from 15th July to 28th September. Date of sowing on 15th July recorded significantly higher number of capitula plant^{-1} (67.6) and number of seeds capitula^{-1} (29.5). Minimum number of capitula plant^{-1} (17.0) and number of seeds capitula^{-1} (16.5) were observed on last date of sowing on 28th September. Similar results were also reported by Agarwal et al. [5]; Jagtap et al. [6]; Nayak and Paikaray [7]; Paul et al. [8]. In case of varieties both the number of capitula plant^{-1} and number of seeds capitula^{-1} were found to be non-significant.

3.4 Seed Yield

The data on influence of date of sowing, variety and their interaction on seed yield is presented in Table 6 and Fig. 6. The first date of sowing on 15th July recorded highest seed yield of 519.0 kg ha^{-1} which was 78% more than that of last date of sowing on 28th September (113.9 kg ha^{-1}) during the year 2015. But during the year 2016, the second date of sowing on 30th July resulted significantly higher seed yield of 716.0 kg ha^{-1} followed by the first date of sowing on 14th August (673.6 kg ha^{-1}). During the year 2017, the seed yield was noticed to range from 227.9 to 498.4 kg ha^{-1}. However, the pooled data analysis revealed that the first date of sowing on 15th July reported to give significantly highest seed yield of 562.9 kg ha^{-1} followed by the second date of sowing on 30th July (496.3 kg ha^{-1}). The seed yield of first date of sowing (15th July) was 12 to 77% higher than other dates of sowing up to the last date of sowing (28th September). Such significant reduction in seed yield of niger due to delay in sowing time has also been reported earlier by Singh et al. [12] and Mandal et al. [13]. The variance in seed output could be attributed to differences in the expression of characteristics under optimal environmental conditions. The higher yield could be due to the optimum temperature in the early sown crop, which was beneficial for the early establishment of the crop and subsequent proper growth, resulting in more height, foliage, and seeds per capitula, which ultimately resulted in higher yield and full expression of the varietal characters during the

favourable conditions that existed during early sown crops. These results were also in conformity with the reports of Mishra et al. [10] in niger and Babalad et al. [14] in soybean. Among the varieties, except during the year 2015, there was no significant difference in seed yield during 2016, 2017 and pooled data analysis. However, Utkal Niger-150 significantly out yielded Deomali with a percent increase of 4% over Deomali.

Table 5. Growth parameters and yield attributes of niger as influenced by date of sowing and variety (pooled data of 3 years)

Treatment	Plant height (cm)	No. of branches per plant	Days to 50% flowering	Days to maturity	No. of capitula per plant	No. of seeds per capitula
Date of sowing (D)						
15th July	225.7	7.8	73	127	67.6	29.5
30th July	202.6	7.0	65	122	58.0	26.0
14th August	170.3	6.3	55	112	47.3	25.2
29th August	145.3	5.6	49	99	35.6	21.3
13th September	106.5	5.3	42	93	30.6	18.8
28th September	68.0	4.5	43	90	17.0	16.5
SEm (±)	5.8	0.2	0.5	0.5	2.4	1.1
CD (p=0.05)	18.4	0.8	1.6	1.5	7.6	3.4
Variety (V)						
Deomali	157.8	6.0	55	108	42.7	23.1
Utkal Niger-150	148.4	6.1	54	106	42.7	22.6
SEm (±)	3.4	0.1	0.3	0.3	0.9	0.5
CD (p=0.05)	10.3	0.4	0.9	0.8	2.7	1.4
Interaction (D X V)						
SEm (±)	8.2	0.3	0.7	0.7	2.1	1.1
CD (p=0.05)	25.4	0.9	2.1	2.0	6.5	3.4
Interaction (V X D)						
SEm (±)	4.8	0.2	0.4	0.4	1.6	0.8
CD (p=0.05)	15.0	0.6	1.3	1.2	5.1	2.4

Table 6. Seed yield (kg ha-1) of niger as influenced by date of sowing and variety

Treatment	Seed yield (kg ha^{-1})			
	2015	2016	2017	Pooled
Date of sowing (D)				
15th July	519.0	671.2	498.4	562.9
30th July	334.1	716.0	438.8	496.3
14th August	296.8	673.6	459.2	476.5
29th August	166.7	576.8	467.7	403.7
13th September	117.2	240.0	424.9	260.7
28th September	113.9	42.4	227.9	128.1
SEm (±)	7.4	27.7	21.5	18.9
CD (p=0.05)	23.3	87.4	67.7	59.5
Variety (V)				
Deomali	241.0	480.0	420.2	380.4
Utkal Niger-150	274.9	493.3	419.0	395.7
SEm (±)	8.3	17.9	11.7	12.6
CD (p=0.05)	25.7	55.0	35.9	38.9
Interaction (D X V)				
SEm (±)	20.4	43.7	28.6	30.9
CD (p=0.05)	62.9	134.8	88.0	95.2
Interaction (V X D)				
SEm (±)	9.4	24.0	17.0	16.8
CD (p=0.05)	29.0	74.6	53.1	52.2

Table 7. Net Monetary Return and Benefit: Cost ratio as influenced by date of sowing and variety

Treatment	2015		2016		2017		Mean	
	NMR (Rs ha^{-1})	B:C Ratio	NMR (Rs ha^{-1})	B:C Ratio	NMR (Rs ha^{-1})	B:C Ratio	NMR (Rs ha^{-1})	B:C Ratio
Date of sowing (D)								
15th July	8697	1.7	9897	1.6	5655	1.4	8083	1.6
30th July	1300	1.1	11689	1.7	3252	1.2	5414	1.3
14th August	-192	1.0	9993	1.6	4068	1.3	4623	1.3
29th August	-5398	0.6	6121	1.4	4410	1.3	1711	1.1
13th September	-7378	0.4	-7351	0.6	2694	1.2	-4012	0.7
28th September	-7509	0.4	-15255	0.1	-5184	0.6	-9316	0.4
SEm (±)	156.5	0.02	290.2	0.03	266.4	0.06	237.7	0.04
CD (p=0.05)	493.3	0.08	914.3	0.10	839.4	0.19	749.0	0.12
Variety (V)								
Deomali	-2423	0.8	2249	1.1	2507	1.2	778	1.0
Utkal Niger-150	-1070	0.9	2782	1.2	2459	1.2	1390	1.1
SEm (±)	104.1	0.03	157.6	0.02	96.4	0.03	119.4	0.03
CD (p=0.05)	320.7	0.08	485.7	0.05	296.9	0.10	367.8	0.08
Interaction (D X V)								
SEm (±)	254.9	0.07	386.1	0.04	236.1	0.08	292.4	0.06
CD (p=0.05)	785.6	0.21	1189.6	0.13	727.5	0.25	900.9	0.20
Interaction (V X D)								
SEm (±)	137.9	0.03	230.0	0.03	181.5	0.05	183.1	0.04
CD (p=0.05)	428.9	0.10	717.3	0.08	568.4	0.15	571.5	0.11

Note: NMR= Net monetary return; B:C ratio= Benefit - cost ratio

3.5 Economics

15th July date of sowing recorded significantly higher NMR during the year 2015 and 2017 (Table 7). The mean data showed that the sowing of niger on 15th July recorded highest NMR of Rs.8083 ha^{-1} and B:C ratio 1.6 followed by 30th July and 14th August with NMR Rs.5414 ha^{-1} and Rs.4623 ha^{-1}, respectively and B:C ratio 1.3 which was superior over rest of the dates of sowing. The last two dates of sowing (13th and 28th September) of niger showed negative NMR due to much delayed in date of sowing. In case of varieties Utkal Niger-150 recorded significantly higher NMR of Rs. 1390 ha^{-1} with B:C ratio 1.1.

4. CONCLUSION

Based on the luxurious growth in the first sown crop associated with higher amount of rainfall, sunshine hours and optimum growing condition and yield attributes, seed yield and economic indices, it can be concluded that the most suitable date of sowing niger variety Utkal Niger-150 is 15th July for getting higher seed yield and monetary returns under Eastern Ghat High Land zone of Odisha.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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