



# Effect of Spacing and Planting Time on Growth, Yield and Yield Components of Mustard (*Brassica nigra* L.) Cultivar in Unwana, Ebonyi State, Nigeria

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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 conducted at the Department of Horticulture and Landscape Technology teaching and research farm during 2022 cropping season, to investigate the effect of spacing and planting time on the growth, yield and yield components of mustard in Unwana agro-ecology of Southeastern Nigeria. Two (2) planting time and six (6) plant spacings were evaluated in a split-plot fitted in a randomized complete block design (RCBD) with three (3) replications. The factor A was time of planting (March and August), which occupied the main plot while factor B which was plant spacing (20x15cm, 30x15cm, 40x15cm, 50x15cm, 60x15cm and 70x15cm) occupied the sub-plots.

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Data were collected on plant height, leaf number, total yield, straw yield, oil yield and oil content at harvest. Result obtained showed that the growth, yield and yield components of mustard were significantly ( $P < 0.05$ ) improved by time of planting and plant spacing used. March time of planting increased seed yield and yield components seed yield ( $102.90\text{gha}^{-1}$ ), straw yield ( $25.97\text{gha}^{-1}$ ), oil yield ( $654.10\text{kg/ha}$ ), and oil content ( $41.56\%$ ) than August planting time ( $39.40\text{gha}^{-1}$ ,  $20.93\text{gha}^{-1}$ ,  $477.50\text{kg/ha}$  and  $39.02\%$  seed yield, straw yield, oil yield and oil content, respectively). On the other hand, result revealed that the plot planted with  $20 \times 15$  plant spacing significantly increased the plant height and leaf number ( $18.98\text{cm}$  and  $16.62$ ) at 4WAP, respectively with the corresponding total yield ( $103.20\text{gha}^{-1}$ ) than other plant spacing used. The result showed that it was more productive to grow mustard at closer spacing ( $20 \times 15\text{cm}$ ) as depicted by the yield and yield components advantages.

**Keywords:** *Brassica nigra* L.; spacing; plant time; growth; yield; yield components.

## 1. INTRODUCTION

Mustard (*Brassica nigra* L) is one of the most important oilseed crops belonging to the family Brassicaceae, formally *Cruciferae*. It is the second most important edible oilseed crop after groundnut [1]. Mustard is used in the production of vegetable oil and bio-diesel [2]. Mustard oil is dominantly used in the food beverage industry and pharmaceuticals. It also accounts for several applications, such as anti-bacterial agents, anti-fungal agents, and in soap production. The oil is also used in cooking food and to increase the taste. Currently, about 17.84% of annual edible oil in the world comes from mustard crop [3]. Planting patterns plays an important roles in enhancing overall productivity of crops as it is likely to affect light interception, absorption, penetration and utilization of solar radiation. The seed yield and the oil quality depend on the genetic, ecological and agronomic factors [4]. Temperature is a major factor that affects and determines crop growth, development and productivity [5]. Variation in maximum and minimum temperatures alters the growth and development pattern of mustard plant by affecting the duration and onset of different phenophases [6]. Different sowing dates provide variable environmental conditions within same location for growth and development of crop. Late sowing of mustard decreased seed yield through synchronization of siliqua filling period with high temperatures, decrease in assimilate production, shorten siliqua filling period and accelerate plant maturity being a thermo-sensitive and photosensitive crop [7]. Optimum sowing time is one of the most important agronomic practices that has noticeable impact on crop productivity. Planting dates significantly affects growth character, yield and yield components of crops [1], and different sowing dates, seasons, and locations might cause different environmental conditions to mustard,

beginning from seed emergence to maturity. The accumulation of growing degree days (GDD) determines the maturity and yield of crop. Mustard cultivars have different and specific growing degree days requirement for emergence, flowering and maturity [8].

Plant density is another important character, which can be manipulated to attain maximum production per unit area of land. The optimum plant density with proper geometry of planting is dependent on variety, its growth habit and agro-climatic conditions. It is also a fact the, specified variation do not exhibit the same phenotypic characteristics in all the environmental conditions. Improved cultivars is an important tools that geared production in addition to other factors such as good agronomic practices (GAP) and crop environment. Sowing dates and plant density have been shown to provide differential growth conditions. The appropriate sowing date and spacing are very important since it ensures good seed germination, timely appearance of seedlings and optimum development of the root system. Moreover, adopting proper management practices such as spacing, seed rate and cultural practices ensures greater growth of both aerial and underground parts of plant, as well as yield through efficient utilization of growth resources. There is a great need to increasing mustard yield by improving on the management practices such as appropriate time of planting and plant spacing. Such information is lacking under the existing agro-ecological conditions of Unwana. Keeping the above facts in view, the present investigation was carried out using mustard as a test crop.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Location

The field experiment was conducted during 2022 cropping season at the Department of

Horticulture and Landscape Technology, Akanu Ibiam Federal Polytechnic, Unwana, Ebonyi State, teaching and research farm (5°48'N, 7°55'E, 300m above sea level) in the tropical humid rain forest agro-ecological zone of Southeastern Nigeria, to determine the effect of planting time and plant spacing on growth, yield and yield components of mustard. The experimental area has mean annual rainfall of 3500mm and mean daily temperature range between 27°C to 38°C [9]. The soil is hydromorphic belonging to the order ultisol classified as clayey-loam [10]. The vegetation is characterized with tall grasses, shrubs and trees.

## 2.2 Experimental Design and Treatments

The experimental design used was split-plot fitted in a randomized complete block design (RCBD) with two different times of planting (March and August) as factor A treatment constituting the main plot while six different plant spacing as factor B (20x15cm, 30x15cm, 40x15cm, 50x15cm, 60x15cm and 70x15cm) constituted the sub-plots with three replications in each main plot. Thus, plant population for each plant spacing were 333,333; 222,222; 166,666; 133,333; 111,111 and 95,238 plants/ha, respectively. The plot size used was 2.4m x 2.4m (5.76m<sup>2</sup>).

## 2.3 Planting Methods

Mustard seeds were collected from the Federal College of Agriculture, Ishiagu, Ebonyi State and were planted on 2.4m long ridge. However, before planting, the seeds were soaked in water for two hours (to ensure good germination), and were treated with Aldrex T fungicide at the rate of 2g/kg of seed, and were sown three seeds per hole and later thinned to one plant/stand at two weeks after planting (WAP).

## 2.4 Soil Sample Collection and Analysis

Prior to planting, soil samples were collected from the site at a depth of 0 -20cm from different locations and was thoroughly mixed together to form composite soil sample and the sample was processed and analyzed for physico-chemical properties.

## 2.5 Field Maintenance

Manual hoe weeding was done at 3, 8 and 12 weeks after planting (WAP), and the ridges remolded at each weeding period. Compound fertilizer (common dose) of 40kgN, 30kgP<sub>2</sub>O<sub>5</sub> and

20kgK<sub>2</sub>Oha<sup>-1</sup> was applied in all the treatments by band placement method at 3 WAP as a basal application. The crop was generally raised as per recommended practices.

## 2.6 Data Collection and Analysis

Data on plant height and leaf number were taken at 2, 4, 6 and 8 WAP. Pod and seed weights were determined from the net plot area, respectively. However, the seed weight was obtained after threshing and sun drying of the pod to reduce moisture level. The oil percent in the seed was determined by Soxhlet's extraction method. All the data obtained were statistically analyzed using the procedure outlined by Obi [11] for RCBD and significant mean differences were detected by Fishers least significant difference (F-LSD) at P<0.05% probability level.

## 3. RESULTS AND DISCUSSION

### 3.1 Soil and Weather Data

The results obtained (Table 1) shows the mechanical and chemical analyses of the soil of the experimental site was clayey-loam with acidic reaction (pH 4.20, 3.90 and 4.01, 3.42) H<sub>2</sub>O and CaCl<sub>2</sub> pre and post planting, respectively. The soils were low to moderate in nutrient contents with organic carbon (1.43 and 1.00%), organic matter (2.47 and 1.79%), total nitrogen (0.16 and 0.23%), available P (9.27 and 8.77mg/kg) and exchangeable potassium (0.12 and 0.14cmol/kg) in both pre and post harvesting, respectively. This is an indication of low soil fertility status. The low nitrogen content less than the critical level of 1.00% could be as a result of high mineralization and subsequent high rate of leaching [12], probably due to rains in the area being high from April to October (Table 2).

The highest total rainfall (381.26mm) and (356.33mm) in October and April, respectively while the lowest (0.30mm) was in December. The highest temperature (34°C) was recorded in March and the lowest (29°C) was in August and September. The climatic data revealed that there was heavy rainfall and high temperature during the period of the experiment.

### 3.2 Mustard Growth

Plant height of mustard was not significantly affected by planting time and plant density at 2, 6 and 8 WAP. However, at 4WAP, there was significant (P<0.05) improvement on plant height

due to different plant density, and the interaction on the planting dates and plant density also indicated significant effect on plant height. Generally, the highest mean plant height value (5.72 cm), followed by (5.44cm) was recorded in plots planted with 40x15 and 2015cm plant spacing at 2WAP, respectively, while the lowest value (5.14cm) was obtained in 30x15cm plot. The results (Table 3) also shows that there was no significant ( $P<0.05$ ) on mustard plant height on both dates and plant density. However, March planting date had the highest (32.65cm) mean height while August planting date had the least (31.62cm) plant height. The highest mean value (33,44cm

and 32.57cm) plant height was recorded on 20x15cm and 30x15cm plant density, respectively. While the lowest mean value (31.14cm) plant height was recorded on 40x15cm plant density.

The effect of planting dates on plant height of mustard was found to be statistically significant. March date of planting time recorded highest plant height than August planting date across all the weeks under study. Time of sowing is very important for mustard production. The increase in plant height could be as a result of different environmental conditions of the study area.

**Table 1. Soil physico-chemical properties of pre and post-harvest of the study site**

Properties	Unit	Pre	Post
Sand	%	38.41	38.20
Silt	%	26.77	21.66
Clay	%	34.82	40.14
Texture		Clayey-loam	Clayey-loam
pH (H <sub>2</sub> O)		4.20	4.01
pH (CaCl <sub>2</sub> )		3.90	3.42
Organic carbon	%	1.43	1.00
Organic matter	%	2.47	1.79
Total nitrogen	%	0.16	0.23
Avail. P	mg/kg	9.27	8.77
Ca	cmol/kg	2.03	1.60
Mg	cmol/kg	1.10	0.99
K	cmol/kg	0.12	0.14
Na	cmol/kg	0.02	0.01
Exch. Acidity		2.19	3.01
ECEC	cmol/kg	5.46	5.75
Base saturation	%	59.87	47.65

**Table 2. Meteorological data of the site during the period of the experiment**

Month	Rainfall (mm)	Ambient Temperature (°C)	Relative humidity (%)
January	0.76	33	73.29
February	32.30	33	76.00
March	86.31	34	73.65
April	356.33	33	74.88
May	243.55	31	97.90
June	325.77	31	77.69
July	206.55	30	79.68
August	276.83	29	80.00
September	268.02	29	79.07
October	381.26	31	76.94
November	0.32	32	65.47
December	0.30	32	70.14
Total	2078.30	378	907.69

Source: AIFPU Met Station, 2022

**Table 3. Effect of different time of planting and plant density on plant height at 2, 4, 6 and 8 weeks after planting (WAP)**

<b>Planting</b>	<b>Spacing</b>						
<b>Time/statistics</b>	<b>20x15</b>	<b>30x15</b>	<b>40x15</b>	<b>50x15</b>	<b>60x15</b>	<b>70x15</b>	<b>Mean</b>
<b>2WAP</b>							
March	7.57	7.67	7.83	8.00	7.87	7.07	7.67
August	3.73	2.60	3.60	2.33	3.00	3.33	3.10
<b>Mean</b>	<b>5.65</b>	<b>5.14</b>	<b>5.72</b>	<b>5.17</b>	<b>5.44</b>	<b>5.20</b>	<b>5.39</b>
LSD <sub>0.05</sub> for time of planting							ns
LSD <sub>0.05</sub> for plant density							ns
LSD <sub>0.05</sub> for time x density							ns
<b>4WAP</b>							
March	17.97	15.30	14.43	15.43	15.80	14.27	15.53
August	20.00	16.37	14.10	12.17	2.33	3.04	11.34
<b>Mean</b>	<b>18.98</b>	<b>15.83</b>	<b>14.27</b>	<b>13.80</b>	<b>9.07</b>	<b>8.66</b>	<b>13.43</b>
LSD <sub>0.05</sub> for time of planting							ns
LSD <sub>0.05</sub> for plant density							0.001
LSD <sub>0.05</sub> for time x density							0.003
<b>6WAP</b>							
March	26.07	25.67	23.70	23.33	22.97	22.53	24.04
August	27.07	25.17	24.00	23.63	25.83	28.50	25.70
<b>Mean</b>	<b>26.57</b>	<b>25.42</b>	<b>23.85</b>	<b>23.48</b>	<b>24.40</b>	<b>25.52</b>	<b>24.87</b>
LSD <sub>0.05</sub> for time of planting							ns
LSD <sub>0.05</sub> for plant density							ns
LSD <sub>0.05</sub> for time x density							ns
<b>8WAP</b>							
March	33.57	34.70	32.40	31.43	32.47	31.30	32.65
August	33.30	30.43	29.87	29.97	31.67	34.50	31.62
<b>Mean</b>	<b>33.44</b>	<b>32.57</b>	<b>31.14</b>	<b>30.70</b>	<b>32.07</b>	<b>32.90</b>	<b>32.14</b>
LSD <sub>0.05</sub> for time of planting							Ns
LSD <sub>0.05</sub> for plant density							Ns
LSD <sub>0.05</sub> for time x density							Ns

**Table 4. Effect of different time of planting and plant density on leaf number at 2, 4, 6 and 8 weeks after planting (WAP)**

Planting Time/statistics	Spacing						Mean
	20x15	30x15	40x15	50x15	60x15	70x15	
<b>2WAP</b>							
March	8.23	8.40	9.03	8.70	8.60	8.67	8.61
August	6.47	6.50	7.20	4.87	6.00	6.17	6.20
<b>Mean</b>	<b>7.35</b>	<b>7.45</b>	<b>8.12</b>	<b>6.78</b>	<b>7.30</b>	<b>7.42</b>	<b>7.40</b>
LSD <sub>0.05</sub> for time of planting							0.001
LSD <sub>0.05</sub> for plant density							ns
LSD <sub>0.05</sub> for time x density							ns
<b>4WAP</b>							
March	17.13	16.93	15.63	17.27	17.20	16.27	16.74
August	16.10	14.03	15.07	13.30	14.50	16.00	14.83
<b>Mean</b>	<b>16.62</b>	<b>15.48</b>	<b>15.35</b>	<b>15.28</b>	<b>15.85</b>	<b>16.13</b>	<b>15.79</b>
LSD <sub>0.05</sub> for time of planting							ns
LSD <sub>0.05</sub> for plant density							ns
LSD <sub>0.05</sub> for time x density							ns
<b>6WAP</b>							
March	24.90	25.80	23.37	24.83	23.93	24.90	24.62
August	25.13	22.73	23.33	21.63	22.83	24.17	23.31
<b>Mean</b>	<b>25.02</b>	<b>24.27</b>	<b>23.35</b>	<b>23.23</b>	<b>23.38</b>	<b>24.53</b>	<b>23.96</b>
LSD <sub>0.05</sub> for time of planting							ns
LSD <sub>0.05</sub> for plant density							ns
LSD <sub>0.05</sub> for time x density							ns
<b>8WAP</b>							
March	33.50	33.30	31.87	34.13	31.97	37.17	33.66
August	31.10	29.17	30.00	27.20	29.00	31.83	29.72
<b>Mean</b>	<b>32.30</b>	<b>31.23</b>	<b>30.93</b>	<b>30.67</b>	<b>30.48</b>	<b>34.50</b>	<b>31.69</b>
LSD <sub>0.05</sub> for time of planting							Ns
LSD <sub>0.05</sub> for plant density							Ns
LSD <sub>0.05</sub> for time x density							Ns

The result (Table 3) corroborated with that of Singh and Lallu-Singh [6]. Moreover, the increase in height could also be attributed to optimum plant density per unit area which might have ensures proper utilization of growth resources in both aerial and underground levels of development. This agrees with Keiwanrad and Zandi [13], who reported that uniform distribution of seeds per unit area decreased competition among plant population in mustard.

sensitive as well as photo-sensitive nature of the crop. This agrees with Mevada et al. [14], who submitted that delay in sowing cause significant reduction in the length of flowering period.

Results obtained (Table 4) showed significant ( $P < 0.05$ ) improvement on the number of leaves at 2 WAP on the planting times used. Plots grown in March recorded increased on the number of leaves (8.61) higher in the number of leaves (6.20) than those planted in August.

However, there was no significant improvement on the number of leaves due to different in plant density. The result also indicated non-significant ( $P < 0.05$ ) difference across the weeks on the number of leaves on both the dates of planting, planting density as well as the interactions at 4, 6 and 8 WAP. However, March date of planting had higher number of leaves (8.61, 16.74, 24.62 and 33.66) than August date of planting with 6.20, 14.83, 23.31 and 29.72 at 2, 4, 6 and 8 WAP, respectively. Generally, the result (Table 4) showed increase in the number of leaves with plant density of 20x15cm (16.62, 25.02 and 32.30) across 4, 6 and 8 WAP than other plant density, except in 2 WAP. The lowest leaf number was observed when mustard was sown at plant density of 50x15cm across 2,4 and 6WAP except on plant density of 60x15cm at 8WAP.

However, increasing the population density of mustard also increased plant height and leaf

number. This is contrary to the work of Muoneke and Mbah [15], who reported that increased population density of okra in an intercrop progressively increased plant height but reduced the leaf number per plant. The increased in the number of leaves could be due to increased interception of solar radiation. The remarkable increase in plant height and leaf number in the case of plant density could have acceleration of cell division and elongation as earlier reported by Chaudhary and Bhagal [16].

Moreover, due to the increase in leaf formation per plant (Table 4) across different plant density, the photosynthetic surface area of the leaves per plant might have been high. This shows that irrespective of the plant density, the leaf of mustard is the factory for the conservation of solar energy into chemical energy by the process of photosynthesis.

### 3.3 Mustard Yield and Yield Components

The total seed yields of mustard per plant were not affected significantly in both planting dates and plant density (Table 5). Mustard cultivated in the month of March produced higher yield ( $102.90\text{gha}^{-1}$ ) than the one planted in the month of August that had  $39.40\text{gha}^{-1}$  of seeds. The difference in the seed weight might be due to the environmental conditions, mostly observed during the plant life cycle. However, the seed

yield is the function of combined effects of all the yield components under the influence of variable environmental conditions. This is in line with the work of Patel et al. [17], who reported that different sowing dates provides variable environmental conditions within the same location growth and development of crop. The decrease in seed yield due to late sowing might have been as a result of synchronization of siliqua filling period, decrease in assimilates production, shortened siliquae filling period and acceleration of plant maturity due to its thermos- The results (Table 5) also indicated that  $20\times 15\text{cm}$  plant density produced the highest yield ( $103.20\text{gha}^{-1}$ ) of mustard seeds while plant density had the least ( $52.15\text{gha}^{-1}$ ) seeds. This could be attributed to optimum plant population, agro-climatic conditions and genotype of the plant which might have influence on the yield-attributing potentials and physiological processes controlled by both genetic make-up and environmental conditions. This agrees with Kanaujia et al. [18], who reported that the difference in genotype of mustard have been found to differ significantly in the yield attributing characters. Yield and its development process in mustard like other crops depend on genetic, environmental and agronomic factors (such as row spacing, seed rate, fertilization) as well as interaction between them. This fact has also been observed by several researchers [13,19].

**Table 5. Effect of different time of planting and plant density on seed yield and yield components of mustard ( $\text{gha}^{-1}$ )**

Treatments	Total yield ( $\text{gha}^{-1}$ )	Straw yield ( $\text{gha}^{-1}$ )	Oil yield (kg/ha)	Oil content (%)
<b>Time</b>				
March	102.90	25.97	654.10	41.56
August	39.40	20.93	477.50	39.02
<b>Mean</b>	<b>71.20</b>	<b>23.45</b>	<b>565.80</b>	<b>40.29</b>
LSD <sub>0.05</sub> for time of planting	Ns	0.07	0.09	0.07
LSD <sub>0.05</sub> for plant density	Ns	0.04	0.21	0.08
<b>Plant spacing (cm)</b>				
20x15	103.20	25.20	600.08	40.46
30x15	85.00	23.59	547.80	40.23
40x15	73.00	21.61	504.50	40.03
50x15	63.00	19.49	459.05	39.81
60x15	50.85	17.10	331.73	35.55
70x15	52.15	15.56	303.15	29.03
<b>Mean</b>	<b>71.20</b>	<b>20.43</b>	<b>457.72</b>	<b>37.51</b>
LSD <sub>0.05</sub> for time of planting	Ns	0.06	0.62	0.07
LSD <sub>0.05</sub> for plant density	Ns	0.02	0.44	0.04
LSD <sub>0.05</sub> for time x density	Ns	Sig.	Sig.	Sig.

Plant density might have influenced mustard seed yield and yield components in one way or the other. The closest spacing (20x15cm to 40x15cm) increased all the yield attributes of mustard up to significant extent over the widest plant spacing (60x15 and 70x15cm). Under the closest spacing between rows, the highest straw yield, oil yield and oil content may be attributed to the reduced competition between plants for growth resources (space, light, nutrients, and soil moisture). This means that the yield components were not influenced by the plant density. This might have had a significant role in regulating the photosynthesis, enhanced the metabolic activities by promoting chlorophyll formation and photosynthesis as well as root development through accelerated nutrients absorption, translocation, resulting to higher yield-attributing characters of mustard. The result is in contrary to the work of Chhonkar et al. [20], who stated that wider spacing between rows increased number of siliqua per plant.

The higher productivity in the case of closer spacing might be attributed to increase vegetative growth which could be as a result of availability of solar radiation. The yield obtained from both the dates and plant density might also be due to physiological role in increased synthesis and partitioning of the biomass activated by the environment of the crop. Mustard requires appropriate space between plants for proper yield. This could be the reason for the high yield in closer spacing between plants. The increase in grain, straw, oil yields and oil content was mainly due to increase in the plot population per unit area. The yield indicated enhanced transformation of biomass into seeds. The interaction between dates and plant density were found to be significantly positive in straw, oil yield and oil content. This shows the synergistic relationship between dates of planting and closer plant densities. It is believed that wider plant density per unit area could not compensate the yields obtained from the closer plant spacing with higher number of plants/unit area. This result is in agreement with the work of Mevada et al. [14]. Also, the variation in grain oil content among the treatment used could be attributed to variation in the synthesis of fatty acids and their esterification by accelerating biochemical reactions in glyoxalate cycle.

#### 4. CONCLUSION

The result confirmed that mustard grown in March with plant density of 20x15cm is promising

and advantageous in productivity. Therefore, for maximum production of full potentials of mustard, good planting time and plant density is recommended as shown from the result of the study.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. Al-Doori SM. Influence of sowing dates on growth, yield and quality of some flax (*Linum usitatissimum* L.) Genotypes. College of Basic Education Researcher Journal. 2012;12(1):733 – 746.
2. Mao S, Han Y, Wu X, An T, Tang J, Shen J, Li Z. Comparative genomic in-situ hybridization analysis of the genomic relationship among *Sinapsis arvensis*, *Brassica rapa* and *Brassica nigra*. *Herditas* (Lund) 2012;149(3):86 – 90.
3. Chauhan SK. Performance of mustard genotype in saline water irrigation in semi-arid zone of western Uttar Pradesh, *Annals of plant and Soil Research*. 2017;19(3):336 – 337.
4. Johnson BI, Kakaria AKM, Hanson BK. Row spacing interaction on spring canola performance in the North Grent plains. *Agronomy Journal*. 2003;95(3):703 – 708.
5. Kaleem S, Hassan FU, Saleem A. Influence of environmental variations on physiological attributes of sunflower. *African Journal of Biotechnological* 2009;8: 3531 – 3539.
6. Singh MP, Lallu-Singh NB. Thermal requirement of Indian mustard (*Brassica juncea*) at different phenological stages under late sown conditions. *Indian Journal of Plant Physiology*. 2014;19(3):238 – 243.
7. Angreji S, Dhingra KK, Jagroop S, Singh MP, Singh J, Singh A. Effect of sowing time and plant density on growth yield and yield quality of Ethiopian mustard (*Brassica cerinata*). *Journal of Research, Punjab*



- Agricultural University. 2002;39(4):471–475.
8. Wahhah MA, Mondal MRI, Akbar MA, Alam MS, Ahmed MU, Begum F. Status of oil crop production in Bangladesh. Oil seed Research Centre, *Bangladesh Agric. Research Institute*, Joy Debpur, Gazipur. 2002:9–10.
  9. NIMET (2003). National Meteorological Bulletin, Meteorological Station, Afikpo, Ebonyi state.
  10. Obasi AI, Eijpe II, Iqwe EN, Nnachi EE. The physical properties of soils within major dumpsites in Abakaliki urban, Southeastern Nigeria and their importance to ground water contamination. *International Journal of Agric. and Forestry* 2005;5(1):17–22.
  11. Obi IU. Introduction to factorial experiment for agricultural, biological and science research. 2<sup>nd</sup> edition, Optional Computer Solution Ltd, Enugu, Nigeria. 2002;99.
  12. Essien BA, Essien JB, Egbadon D. Influence of different levels of NPK 15:15:15 fertilizer on the growth and yield of Roselle (*Hibiscus sabdariffa* L) in Unwana, Afikpo, Ebonyi State. Proceedings of Crop science Society of Nigeria (CSSN) national Annual conference, Owerri. 2019:89 – 94.
  13. Keiwanrad S, Zandi P. Effect of nitrogen levels on growth, yield and oil quality of Indian mustard grown under different plant densities. *Cercetari Agronomic in Moldova*. 2014;1(157):81 – 85.
  14. Mevada KD, Parmar BG, Patel HK, Patel PD. Response of Linseed to different sowing dates and seed rates under middle Gujarat conditions. *Crop Research*. 2017; 52(4 &5):150 – 154.
  15. Muoneke CO, Mbah EU. Productivity of cassava/okra intercropping systems as influenced by okra planting density. *African Journal of Agricultural Research*. 2007;2 (5):223 – 231.
  16. Choudhary S, Bhogal NS. Effect of boron on yield, quality and its uptake in Indian mustard genotypes. *Annals of Plant and Soil Research*. 2017;19 (4):394 – 397.
  17. Patel N, Tyagi PK, Shukla, KC. Effect of sowing dates and varieties on total dry matter and its partitioning in different plant parts and yield of Indian mustard. *Annals of Plant and Soil Research*. 2015; 17(4):413 – 417.
  18. Kanaujia SP, Yoobiangmi L, Jha Asatik. Performancr of various genotypes of green mustard under foothill conditions of Nagaland. *Annals of Plant and Soil Research*. 2017;19 (4): 389 – 393.
  19. Sahu J, Thakur NS, Gupta S. Physiological parameters, yield and economics of Safflower cultivars as affected by sowing dates. *Annals of Plant and Soil Research*. 2017;19 (1):121–123.
  20. Chhonkar DS, Shroti SK, Sharma B. Response of cotton varieties to dates of sowing and planting density under semi-arid condition. *Annals of Plant and Soil Research*. 2011;13(1):62–64.

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