Effect of planting time and harvest on yield and quality of ginger (Zingiber officinale Rosc.) cv. Nadia

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Abstract
In the present study, the effect of different planting time and harvest on yield and quality of ginger (Zingiber officinale Rosc.) cv. Nadia were evaluated. The experiment was laid out in Split Plot Design with dates of planting as main treatment (30\textsuperscript{th} March, 30\textsuperscript{th} April and 30\textsuperscript{th} May) and five harvesting time as sub-treatments (6 MAP, 7 MAP, 8 MAP, 9 MAP and 10 MAP) with three replications. The study revealed that harvesting time effectively influenced on the quality of ginger. Planting time showed significant effect on almost all the characters except for fibre content. The quality of ginger rhizome such as oil content, dry recovery and oleoresin content had significant influence on both the planting time and the harvesting time. Planting of rhizomes on 30\textsuperscript{th} April resulted better yield and yield attributing characters. Among different harvesting time, harvesting at 8 MAP recorded significantly higher fresh weight of ginger and quality characters. The treatment (M\textsubscript{3}) i.e. April planting time and harvesting at 8 MAP exhibited higher yield and yield attributing characters viz. length of finger (8.69 cm), girth of finger (8.09 cm), fresh weight of rhizome plant\textsuperscript{3} (1310.03 g), yield plot\textsuperscript{1} (11.98 kg), and yield ha\textsuperscript{-1} (31.53 t). Planting in the month of April and harvesting at 9 MAP (M\textsubscript{4}) recorded better quality rhizome with high oil (2.83%), oleoresin (15.74%) and dry recovery (23.83%) with less fibre content (4.9%) followed by planting in April and harvest at 8 MAP (M\textsubscript{3}).

Keywords: Ginger, date of planting, date of harvest, yield and quality, Nadia

Introduction
Ginger (Zingiber officinale Rosc.) belongs to the family Zingiberaceae. The somatic chromosome no. is 2n=22 and is native to tropical region of Southeast Asia. India is the top producing country accounting for 33% of the world’s total ginger production with 0.683 million tonnes. (Anon, 2017) \cite{1}. In India ginger is cultivated in most of the states where Karnataka occupies the maximum area (20,489 ha) and production (1,98,180 t). However, Assam, West Bengal, Maharashtra, Karnataka, Gujarat, Meghalaya and Mizoram together contribute 75% of the country’s total ginger production (Spice Board of India, 2018). Ginger is sensitive to water logging, frost, salinity and tolerant to wind and drought. The crop being a shade loving plant, partial shade increases the rhizome yield of ginger (Jayachandran et al., 1991). It was also reported that the rhizome size and plant spacing have significant influence on the growth and yield of ginger (Monnaf et al., 2010) \cite{2}. Ginger produced of North Eastern Region was reported to have higher oil content (1.6-2.5%) and oleoresin content (5.9-8.56%) than ginger grown from other parts of India, so it have vast scope for dry ginger production, export and where bulk quantities of green ginger are not available in nearby market. Thus to make the crop remunerative, essential oil or ginger oil which is derived from the rhizome of the ginger has earned the nickname “The Oil of Empowerment” for the feeling of confidence that it is known to inspire for its high value, high cost with low volume produce. In NER, Assam ranks first in area as well as production of ginger but productivity was the highest in Mizoram (8.40 t ha\textsuperscript{-1}) followed by Arunachal Pradesh (7.39 t ha\textsuperscript{-1}), Assam and Nagaland (6.99 t ha\textsuperscript{-1}). Among the ginger varieties, improved cultivar such as Nadia which is very fleshy, juicy, lemon flavoured and yield high quantities of dry rhizome, oleoresin and oil, also with less fibre content (4.5%) are in great demand among domestic buyers, exporters and in the market. Rhizomes of this variety are suitable for conversion into candy, cube preserve, ginger powder, drinks, powder makings etc., thereby increasing its potential for export especially to

\textsuperscript{1}Yield per plot (kg)

\textsuperscript{2}Yield ha\textsuperscript{-1} (t)

\textsuperscript{3}Fresh weight of rhizome plant (g)

\textsuperscript{4}Length of finger (cm)

\textsuperscript{5}Girth of finger (cm)
the neighboring countries. The main objective of this investigation was to find out the interaction effect on yield and yield attributes at different time of planting, harvest and interaction effect on quality parameters at different time of planting and harvest.

Materials and Methods
The experiment was conducted at the Research farm of SASRD, Nagaland University located at Medziphema, under foot hill condition of Nagaland at an altitude of 310m above msl and geographically located at 25°45'43''N latitude and 95°53'45''E longitude. The climate is sub-humid tropical with high humidity and moderate temperature (12°C to 32°C) having medium to high rainfall (2000-3000 mm) and R.H of 70% to 80%. The soil of the experimental plot was categorized as sandy loam and well drained. The experiment was layout in Split Plot Design (SPD) with three replications. Each block was divided into 15 equal size- plots. The treatments were randomized by standard procedures as per the design given by (Panse and Sukhatme, 1997) [7]. Healthy rhizome of Nadia variety weighing 25 g were treated with hot water at 51°C constant for 10 minutes and then dried and the treated rhizome were soaked with Trichoderma viride @ 10 g per litre of water for 30 minutes. FYM @20 tonnes per hectare was incorporated and mixed thoroughly with the soil. NPK @100:90:90 kg per ha was applied as per recommended dose. The healthy and treated rhizomes were planted on raised bed of size 1.8 m × 2 m with a spacing of 30 cm × 25 cm at depth of 5-7 cm. The treated rhizome was planted on 30th March, 30th April, 30th May, 2018 respectively. Data were recorded for all the treatments including 4 quality traits from five randomly selected plants of each plant for recording the data related to plant traits viz. Length of finger (cm), Girth of finger (cm), Number of fingers per rhizome, Fresh weight of rhizome per plant (g), Yield per plot (kg), Yield (t ha⁻¹), Fibre content (%), Oleoresin content (%), Oil content (%) and Dry recovery (%) respectively. Fibre content of rhizome was estimated as per the procedure describe by J. S. Purthi on Quality assurance in spice and spice product, 1998.

\[ \text{Fibre content} \% = \frac{A \times 100}{B} \]

Where
A- Denotes fiber content (g) on fresh weight
B- Denotes weight of sample used (g)

The oleoresin content in ginger was estimated as per the procedure suggested by the AOAC (Horwitz, 1980) [3]

\[ \text{Oleoresin content} \% (W/W) = \frac{\text{Wt. of oleoresin (g) } \times 100}{\text{Wt. of the sample (g)}} \]

Oil Content (%) was determined by the formula

\[ X = \frac{A \times 100}{B} \]

Where
X- Denotes volatile oil percentage
A- Denotes volume of volatile oil extracted (ml)
B- Denotes weight of sample used (g)

Results and Discussion
From the observation (Table-1) it was observed that planting time and harvesting time (H) have effective significant on all the yield and yield attributing characters. The maximum mean length of finger, girth of finger, highest number of finger per rhizome, highest fresh weight of rhizomes per plant, yield per plot and maximum yield (t ha⁻¹) was recorded in M3 with 8.47 cm, 7.53 cm, 15.64, 1072.39 g, 9.95 kg and 26.89 t ha⁻¹ the lowest was recorded in M1 with 7.69 cm, 6.83 cm, 12.75, 909.76 g, 7.59 kg and 20.95 t ha⁻¹. The maximum mean length of finger was observed where harvesting was done at 9 MAP (H3) with 8.33 cm while lowest finger length was recorded in 10 MAP (H4) i.e. 7.69 cm. Maximum girth of finger was observed where harvesting was done at 8 MAP (H3) with 7.64 cm. The lowest was recorded where harvesting was done at 10 MAP (H3) with 6.70 cm. The highest mean number of fingers recorded with effect of harvesting time was 15.57 with H3 (8 MAP) treatment and minimum number of fingers were recorded in the treatment H5 (10 MAP) with 13.26. Fresh weight of rhizomes per plant with respect to harvesting time was recorded highest in H1 (8 MAP) with 1076.24 g, 10.01 kg and 26.52 t ha⁻¹. The lowest was recorded in H5 (10 MAP) with 909.94 g. The findings were in conformity with Aggarwal et al. (2002). Effect of harvesting on yield per plot was from H3 (8 MAP) with 10.01 kg and the lowest was observed in H1 (6 MAP) with 7.82 kg. The lowest yield(t ha⁻¹) was observed when harvesting was done from 10 MAP (H5) with 21.24 t ha⁻¹. This is in conformity with the findings of Sangwal et al. (2012) [8].

The interaction between effect of planting time and harvest showed significant for all the yield and yield attributing characters except for the number of fingers per rhizome. The maximum mean length of fingers obtained from M3:H3 and M2:H3 resulted maximum for mean girth of fingers, highest fresh weight of rhizome per plant and highest yield. The number of fingers per rhizome was non-significant for the treatment combination. This may be due to the use of same variety which is genetically similar.

Quality attributes: Data presented in Table-2 showed that planting time and harvesting time have effective significant on all the quality attributes except for the fibre content (%) with planting time. However the highest mean fibre content was recorded from (M3) with 6.11% and the lowest was observed in (M1) with 5.89%. The maximum mean fibre content was observed where harvesting was done from H5 (10 MAP) with 6.70% and the lowest was observed where harvesting was done from H1 (6 MAP) with 5.25%. The findings were in conformity with Sharma (2004). The maximum oleoresin was recorded highest during the planting time of M3 with 13.71% and the minimum was recorded in planting time of M3 with 11.79%. The maximum

| Treatment details |
|--------------------|
| Time of planting (M) | Time of harvesting (H) |
| M1: 30th March | H1: Harvest at 6 Month |
| M2: 30th April | H2: Harvest at 7 Month |
| M3: 30th May | H3: Harvest at 9 Month |
| M4: 20th May | H4: Harvest at 10 Month |

The maximum oleoresin was recorded highest during the planting time of M3 with 13.71% and the minimum was recorded in planting time of M3 with 11.79%. The maximum oleoresin was recorded highest during the planting time of M3 with 13.71% and the minimum was recorded in planting time of M3 with 11.79%.
oleoresin was recorded highest when the harvesting was done from H1 (9 MAP) with 7.17% and lowest was observed from M1H4 with 4.90%. The highest oleoresin content was recorded from M2H4 with 15.74% while the least oleoresin content was recorded in M3H2 with 8.61%. The present findings where in accordance with the findings of (Kumar and Gill, 2009) [4]. The highest oil content (2.83%) was observed in M2H2 and the lowest oil content (1.50%) was observed in M1H2. The highest dry recovery was recorded in M2H2 with 23.83% and the lowest was recorded in M1H1 with 15.13%.

Table 1: Effect of planting time (M) and harvest (H) on length of finger (cm), girth of finger (cm), number of fingers per rhizome, fresh weight of rhizome per plant (g), yield per plot (kg), yield (t ha⁻¹), on fibre content (%), oleoresin content (%), oil content (%) and dry recovery (%)

| Treatment | Length of finger (cm) | Girth of finger (cm) | Number of fingers per rhizome | Fresh weight of rhizome per plant (g) | Yield per plot (kg) | Yield (t ha⁻¹) | Fibre content (%) | Fibre content (%) | Oil content (%) | Oil content (%) | Dry recovery (%) |
|-----------|-----------------------|---------------------|-------------------------------|--------------------------------------|-------------------|----------------|-----------------|-----------------|----------------|-----------------|-----------------|
| M1H1      | 7.95                  | 7.33                | 13.91                         | 927.32                               | 8.15              | 22.42         | 5.89            | 5.89            | 2.03           | 20.34           |
| M2H1      | 8.47                  | 7.53                | 15.64                         | 1072.39                              | 9.95              | 26.89         | 6.09            | 6.09            | 2.23           | 22.11           |
| M3H1      | 7.66                  | 6.83                | 12.75                         | 909.76                               | 7.52              | 20.95         | 6.11            | 6.11            | 1.93           | 20.75           |
| SEm±      | 0.15                  | 0.13                | 0.26                          | 16.56                                | 0.12              | 0.34          | 0.10            | 0.10            | 0.06           | 0.27            |
| CD (P=0.05) | 0.76                  | 0.63                | 1.27                          | 81.87                                | 0.58              | 1.68          | NS              | NS              | 0.29           | 1.33            |
| M1H2      | 7.92                  | 7.06                | 13.42                         | 915.00                               | 7.82              | 21.98         | 5.25            | 5.25            | 1.72           | 19.18           |
| M2H2      | 7.94                  | 7.31                | 14.64                         | 978.91                               | 8.82              | 24.22         | 5.5             | 5.5             | 2.17           | 20.09           |
| M3H2      | 8.25                  | 7.64                | 15.67                         | 1076.24                              | 10.01             | 26.74         | 6.22            | 6.22            | 2.22           | 21.31           |
| SEm±      | 0.15                  | 0.09                | 0.42                          | 27.71                                | 0.18              | 0.94          | 0.14            | 0.14            | 0.14           | 0.72            |
| CD (P=0.05) | 0.5                   | 0.3                 | 1.43                          | 93.69                                | 0.60              | 1.83          | 0.47            | 0.47            | 0.46           | 2.44            |

Table 2: Interaction effect on planting time (M) and harvest (H) on length of finger (cm), girth of finger (cm), number of fingers per rhizome, fresh weight of rhizome per plant (g), yield per plot (kg), yield (t ha⁻¹), on fibre content (%), oleoresin content (%), oil content (%) and dry recovery (%)

| Treatment | Length of finger (cm) | Girth of finger (cm) | Number of fingers per rhizome | Fresh weight of rhizome per plant (g) | Yield per plot (kg) | Yield (t ha⁻¹) | Fibre content (%) | Oleoresin content (%) | Oil content (%) | Dry recovery (%) |
|-----------|-----------------------|---------------------|-------------------------------|--------------------------------------|-------------------|----------------|-----------------|----------------------|-----------------|-----------------|
| M1H1      | 7.19                  | 6.77                | 12.8                          | 912.2                                | 7.48              | 21.26         | 4.9             | 8.61                 | 1.67            | 15.13           |
| M2H1      | 8.01                  | 7.36                | 13.93                         | 916.8                                | 7.78              | 21.61         | 5.5             | 12.24                | 2               | 19.85           |
| M3H1      | 8.53                  | 7.65                | 15.4                          | 980.7                                | 9.51              | 25.81         | 5.87            | 14.38                | 1.83            | 21.56           |
| M1H2      | 8.15                  | 7.53                | 13.13                         | 917.1                                | 7.7               | 21.38         | 3.66            | 14.97                | 2.17            | 23.57           |
| M2H2      | 7.87                  | 7.33                | 14.27                         | 909.8                                | 8.27              | 22.05         | 6.83            | 14.12                | 2.5             | 21.57           |
| M3H2      | 8.21                  | 7.08                | 14.8                          | 925.03                               | 8.61              | 24.23         | 5.42            | 13.59                | 2               | 22.23           |
| M1H3      | 8.45                  | 7.94                | 16.27                         | 1105.13                              | 10.97             | 29.35         | 5.09            | 13.54                | 2.17            | 20.63           |
| M2H3      | 8.51                  | 8.09                | 17.2                          | 1310.03                              | 11.98             | 31.53         | 6.03            | 13.1                 | 2.5             | 23.44           |
| M3H3      | 8.69                  | 7.67                | 15.6                          | 1074.96                               | 9.9               | 27.24         | 6.78            | 15.74                | 2.83            | 23.83           |
| M1H4      | 8.49                  | 6.88                | 14.33                         | 946.8                                | 8.3                | 22.13         | 7.17            | 12.5                 | 1.67            | 20.41           |
| M2H4      | 8.36                  | 7.34                | 12.67                         | 907.77                               | 7.36              | 20.46         | 5.43            | 9.13                 | 1.5             | 20.17           |
| M3H4      | 7.37                  | 6.62                | 13.73                         | 914.8                                | 7.71              | 21.68         | 5.8             | 12.1                 | 2.33            | 19.8            |
| M1H5      | 7.71                  | 7.17                | 14.4                          | 938                                  | 8.55              | 22.88         | 6.78            | 10.68                | 2.33            | 18.91           |
| M2H5      | 8.14                  | 7.14                | 11.73                         | 905                                  | 7.26              | 20.18         | 6.32            | 14.74                | 1.83            | 23.38           |
| M3H5      | 6.71                  | 5.87                | 11.2                          | 883.23                               | 6.7               | 19.55         | 6.11            | 12.32                | 1.67            | 21.48           |
| SEm±      | 0.26                  | 0.15                | 0.73                          | 47.99                                | 0.31              | 0.94          | 0.24            | 0.90                 | 0.24            | 1.25            |
| CD (P=0.05) | 0.86                  | 0.52                | NS                            | 162.28                               | 1.03              | 3.16          | 0.81            | 3.04                 | 0.39            | 4.22            |
From the result of the investigation, it was concluded that planting during April and harvesting at 8 MAP (i.e., December) recorded the highest yield however, in respect to the quality characters viz., essential oil, oleoresin content and dry recovery showed better value during April planting and harvested at 9 MAP for ginger cv. Nadia.

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