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RESEARCH PAPER

# Periodical dry matter accumulation and partitioning in Indian mustard [*Brassica juncea* (L.)] varieties as affected by limited irrigation and nitrogen levels

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***Abstract*** **:** A field experiment was conducted during the *Rabi* season of 1999-2000 and 2000-2001 at Hisar to study the effect of limited irrigation and nitrogen levels on periodical dry matter accumulation and its partitioning in Indian mustard varieties. The variety Laxmi recorded significantly higher dry matter accumulation at all growth stage except at 30 days after sowing. The proportion of dry matter allocation (%) was higher in the variety Laxmi than the variety RH-9304. The dry matter accumulation and its partitioning in different plant parts were clearly distinct under irrigated as compared to unirrigated environment. The proportion of dry matter allocation was higher in one irrigation applied at flowering stage than other irrigation levels. Increasing nitrogen levels, at all growth stage increased dry matter production and higher distinct partitioning values to different plant organs were observed up to 100 kg. $Nha^{-1}$.

***Key Words*** **:** Dry matter accumulation, Dry matter partitioning, Limited irrigation, Nitrogen level, Indian mustard

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## INTRODUCTION

Oilseed crops play an important role in Indian agriculture. Out of five important oilseed crops *viz*., groundnut, rapeseed-mustard, linseed, sesamum and castor grown in the country, rapeseed-mustard occupy a prestigious position and rank second after groundnut. Among the *Rabi* oilseed crops, cultivation of Indian mustard was found more profitable even with limited water along with fertilizer application (Sharma, 1991). Plant genotype, nitrogen use and water-use, these can not be considered in isolation but the interacting effect of fertilizer nitrogen and efficient management of limited irrigation water on different plant genotype of Indian mustard needs thorough consideration and attention to generate more information on growth and phenology of Indian mustard. Keeping above in view, the present investigation was carried out to study the effect of limited irrigation and fertilizer nitrogen on relative performance of Indian mustard varieties with respect to dry matter accumulation and its partitioning in different plant parts.

## MATERIALS AND METHODS

A field experiment was conducted in a split-plot design with three replications during the *Rabi* seasons of 1999-2000 and 2000-2001 at the Agronomy Research Farm of CCS Haryana Agricultural University, Hisar. The soil of the experimental field was sandy loam in texture with 172 and 168 kg/ha available N, 16 and 14 kg/ha available P, 381 and 379 kg/ha available K during 1999-2000 and 2000-2001, respectively. The experiment consisted of two Indian mustard varieties *viz.,* $V_1$-RH-9304, $V_2$-Laxmi and three irrigation levels *viz*., $I_0$-no post sowing irrigation$I_1$-one irrigation (60mm) at flowering stage, $I_2$-one irrigation (60 mm) at siliqua development stage as main plot treatments and six nitrogen levels *viz*., $N_0$-no nitrogen application, $N_1$-40 kg N/ha, $N_2$-60 kg N/ha, $N_3$-80 kg N/ha, $N_4$-

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100 kg. N/ha and $N_5$-120 kg N/ha as sub-plot treatments. Entire nitrogen as per treatment as urea and phosphorus in the form of SSP were applied at sowing. The crop was sown in rows 30 cm apart on 14th and 15th November in 1999 and 2000, respectively in the same field during both the years. The crop was harvested on 1st April, 2000 and 3rd April, 2001, respectively. A measured quantity of water (60 mm depth) in each irrigation was applied as per requirement of treatment. The total rainfall received during the winter season of 1999-2000 and 2000-2001 was 19.0 mm and 15.0 mm, respectively. Periodical changes in dry matter accumulation were recorded taking five selected tagged plants from each plot for each observation. The sample plants of mustard were cut from the ground level (excluding the root portion) for the periodical observations. Leaves were separated and remaining plant portion were air dried first and kept in oven at $60^0$C to constant weight. Dry weight of the leaves and other plant parts were added and averaged to record biomass/plant.

## RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

**Periodical dry matter accumulation:**

The data pertaining to periodical dry matter production (Table 1) of Indian mustard as affected by different treatments showed that dry matter accumulation was higher during 1999-2000 than 2000-2001. Data revealed that dry matter accumulation/plant increased progressively with advancement of crop age during both the years. The variety Laxmi ($V_2$) accumulated significantly higher dry matter at all growth stages except 30 days after sowing (DAS) than the variety RH-9304 ($V_1$) during both the years. This differences in growth may be due to the morphological characters of these varieties. Singh and Kumar (1996) reported that the varieties differed significantly in dry matter accumulation of mustard varieties. Dry matter accumulation due to irrigation treatments at 30 and 60 DAS did not record significant variation (Table 1). However, at subsequent crop growth stages, irrigation levels, $I_1$ had significant variation over $I_0$ and $I_2$ level up to harvest during both the years. At maturity, the dry matter accumulation under $I_1$ and $I_2$ level was 46.41 and 40.15 g/plant in 1999-2000 and 46.29 and 38.85 g/plant in 2000-2001, respectively. The increase in dry matter at $I_1$ and $I_2$ levels were 32.60 and 14.71 per cent higher, respectively, over $I_0$ during 1999-2000; the corresponding valuers being 40.27 and 17.23 per cent for the years 2000-2001. Increasings levels of nitrogen increased dry matter accumulation significantly over no nitrogen application at all the crop growth stage during both the years (Table 1). Nitrogen level ($N_5$) increased dry matter accumulation significantly compared to its lower level ($N_4$, $N_3$, $N_2$, $N_1$ and $N_0$) but remained at par with $N_4$ levels at 30, 60 and 90 DAS. Maximum dry matter accumulation (51.92 and 53.00 g/plant) with 120 kg N/ha ($N_5$) was obtained at harvest during 1999-2000 and 2000-2001, respectively. Significant increase in the dry matter accumulation with the application of nitrogen might be due to fact that nitrogen stimulated plant growth by means of enlarged leaf canopy and greater rate of leaf expansion

**Table 1 : Effect of limited irrigation and nitrogen levels on periodical dry matter production (g/plant) of Indian mustard**

| Treatments | Days after sowing (DAS) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 30 | 60 | 90 | 120 | Maturity | 30 | 60 | 90 | 120 | Maturity |
| **Varieties** | | | | | | | | | | |
| $V_1$ | 1.71 | 11.34 | 27.48 | 37.51 | 39.56 | 1.53 | 10.11 | 26.15 | 36.17 | 38.18 |
| $V_2$ | 1.79 | 12.64 | 29.22 | 39.37 | 41.48 | 1.58 | 11.27 | 28.23 | 38.45 | 40.58 |
| C.D (P=0.05) | NS | 1.13 | 1.51 | 1.76 | 1.62 | NS | 1.12 | 1.73 | 1.95 | 2.15 |
| **Irrigation schedule** | | | | | | | | | | |
| $I_0$ | 1.73 | 11.59 | 24.82 | 33.16 | 35.00 | 1.53 | 10.13 | 23.52 | 31.75 | 33.00 |
| $I_1$ | 1.77 | 12.64 | 32.48 | 44.24 | 46.41 | 1.58 | 11.12 | 31.46 | 43.04 | 46.29 |
| $I_2$ | 1.75 | 12.02 | 27.75 | 37.92 | 40.15 | 1.54 | 10.82 | 26.59 | 37.14 | 38.85 |
| C.D(P=0.05) | NS | NS | 1.52 | 2.85 | 4.52 | NS | NS | 2.34 | 2.52 | 3.74 |
| **Nitrogen levels** | | | | | | | | | | |
| $N_0$-No nitrogen | 1.46 | 6.14 | 16.75 | 24.21 | 25.24 | 1.29 | 5.11 | 15.17 | 20.29 | 21.35 |
| $N_1$-40 kg N/ha | 1.60 | 9.16 | 22.16 | 31.19 | 33.23 | 1.41 | 8.19 | 21.12 | 30.23 | 32.00 |
| $N_2$-60 kg N/ha | 1.68 | 10.17 | 27.32 | 37.42 | 39.56 | 1.49 | 9.26 | 25.45 | 35.56 | 37.45 |
| $N_3$-80 kg N/ha | 1.79 | 12.34 | 30.51 | 41.03 | 43.41 | 1.58 | 11.18 | 28.54 | 39.57 | 41.58 |
| $N_4$-100 kg N/ha | 1.96 | 16.55 | 35.73 | 47.34 | 49.76 | 1.69 | 14.53 | 35.85 | 48.11 | 50.90 |
| $N_5$-120 kg N/ha | 2.01 | 17.58 | 37.63 | 49.45 | 51.92 | 1.84 | 15.67 | 37.01 | 50.10 | 53.00 |
| C.D (P=0.05) | 0.20 | 1.13 | 2.12 | 1.72 | 1.99 | 0.15 | 1.16 | 1.17 | 1.76 | 1.97 |

NS=Non-significant

**Table 2 : Effect of limited irrigation and nitrogen levels on dry matter partitioning (g/plant) in different plant of Indian mustard**

| Treatments | 30 days after sowing | | | | 60 days after sowing | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Leaf | | Stem | | Leaf | | Stem | | Reproductive parts* | |
| | 1999-2000 | 2000-2001 | 1999-2000 | 2000-2001 | 1999-2000 | 2000-2001 | 1999-2000 | 2000-2001 | 1999-2000 | 2000-2001 |
| **Varieties** | | | | | | | | | | |
| $V_1$ | 1.11 | 0.90 | 0.60 | 0.63 | 4.42 | 3.79 | 6.11 | 5.71 | 0.81 | 0.61 |
| $V_2$ | 1.16 | 0.93 | 0.63 | 0.65 | 5.16 | 4.17 | 6.49 | 6.42 | 0.99 | 0.68 |
| C.D. (P=0.05) | NS | NS | NS | NS | 0.64 | 0.33 | 0.33 | 0.52 | 1.12 | 0.04 |
| **Irrigation schedule** | | | | | | | | | | |
| $I_0$ | 1.08 | 0.91 | 0.65 | 0.62 | 4.72 | 3.97 | 6.16 | 5.59 | 0.71 | 0.57 |
| $I_1$ | 1.17 | 0.94 | 0.60 | 0.64 | 4.84 | 3.99 | 6.39 | 6.39 | 1.13 | 0.74 |
| $I_2$ | 1.16 | 0.90 | 0.59 | 0.66 | 4.81 | 3.98 | 6.35 | 6.21 | 0.86 | 0.63 |
| C.D. (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **Nitrogen levels** | | | | | | | | | | |
| $N_0$-No nitrogen | 0.90 | 0.75 | 0.56 | 0.54 | 2.26 | 1.82 | 3.59 | 3.14 | 0.29 | 0.15 |
| $N_1$-40 kg N/ha | 0.98 | 0.80 | 0.62 | 0.61 | 3.65 | 2.95 | 5.03 | 4.97 | 0.48 | 0.27 |
| $N_2$-60 kg N/ha | 1.10 | 0.88 | 0.58 | 0.61 | 4.11 | 3.43 | 5.35 | 5.28 | 0.71 | 0.55 |
| $N_3$-80 kg N/ha | 1.19 | 0.94 | 0.60 | 0.64 | 4.89 | 4.25 | 6.41 | 6.35 | 1.04 | 0.78 |
| $N_4$-100 kg N/ha | 1.29 | 1.02 | 0.67 | 0.67 | 6.71 | 5.45 | 8.46 | 8.07 | 1.38 | 1.01 |
| $N_5$-120 kg N/ha | 1.35 | 1.10 | 0.66 | 0.74 | 7.13 | 5.98 | 8.98 | 8.58 | 1.47 | 1.11 |
| C.D (P=0.05) | 0.32 | 0.32 | NS | NS | 0.97 | 0.56 | 0.55 | 0.54 | 0.16 | 0.15 |

*Reproductive parts (Flower buds +flowers) NS=Non-significant

**Table 3 : Effect of limited irrigation and nitrogen levels on dry matter partitioning (g/plant) in different plant parts of Indian mustard varieties**

| Treatments | 90 days after sowing | | | | | | 120 days after sowing | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Leaf | | Stem | | Reprod. Parts* | | Leaf | | Stem | | Reprod. Parts* | |
| | 1999-2000 | 2000-2001 | 1999-2000 | 2000-2001 | 1999-2000 | 2000-2001 | 1999-2000 | 2000-2001 | 1999-2000 | 2000-2001 | 1999-2000 | 2000-2001 |
| **Varieties** | | | | | | | | | | | | |
| $V_1$ | 6.15 | 5.61 | 12.10 | 12.82 | 9.23 | 7.72 | 3.75 | 3.68 | 15.84 | 15.29 | 17.72 | 17.20 |
| $V_2$ | 7.13 | 6.15 | 12.87 | 13.04 | 9.22 | 9.04 | 4.39 | 4.28 | 16.32 | 16.01 | 18.66 | 18.16 |
| C.D. (P=0.05) | 0.85 | 0.48 | 0.72 | 0.19 | NS | 0.96 | 0.58 | 0.54 | 0.44 | 0.62 | 0.52 | 0.84 |
| **Irrigation schedule** | | | | | | | | | | | | |
| $I_0$ | 5.34 | 4.75 | 11.36 | 11.55 | 8.12 | 7.22 | 3.28 | 3.11 | 15.14 | 14.23 | 14.74 | 14.41 |
| $I_1$ | 8.23 | 7.13 | 13.73 | 14.65 | 10.52 | 9.68 | 4.82 | 4.78 | 16.98 | 16.76 | 22.44 | 21.50 |
| $I_2$ | 6.35 | 5.76 | 12.36 | 12.59 | 9.04 | 8.24 | 4.11 | 4.05 | 16.12 | 15.96 | 17.69 | 17.13 |
| C.D. (P=0.05) | 0.98 | 0.98 | 0.97 | 0.89 | 0.88 | 0.89 | 0.65 | 0.67 | 0.82 | 0.54 | 1.62 | 1.84 |
| **Nitrogen levels** | | | | | | | | | | | | |
| $N_0$-No nitrogen | 3.23 | 2.91 | 8.64 | 7.85 | 4.88 | 4.41 | 1.98 | 1.95 | 11.81 | 9.85 | 10.42 | 8.49 |
| $N_1$-40 kg N/ha | 4.76 | 4.21 | 10.88 | 10.73 | 6.52 | 6.18 | 2.61 | 2.48 | 14.39 | 13.51 | 14.19 | 14.24 |
| $N_2$-60 kg N/ha | 6.19 | 5.21 | 12.58 | 12.36 | 8.55 | 7.88 | 3.67 | 3.59 | 15.68 | 15.42 | 18.07 | 16.55 |
| $N_3$-80 kg N/ha | 7.37 | 6.26 | 12.88 | 13.37 | 10.26 | 8.91 | 4.56 | 4.28 | 16.31 | 16.58 | 20.16 | 18.71 |
| $N_4$-100 kg N/ha | 8.85 | 8.12 | 14.86 | 16.53 | 12.02 | 11.21 | 5.64 | 5.47 | 18.77 | 18.73 | 22.93 | 23.91 |
| $N_5$-120 kg N/ha | 9.46 | 8.57 | 15.07 | 16.72 | 13.10 | 11.72 | 5.96 | 6.11 | 19.54 | 19.81 | 23.95 | 24.18 |
| C.D (P=0.05) | 0.64 | 0.48 | 0.28 | 0.21 | 1.16 | 0.52 | 0.29 | 0.66 | 0.78 | 1.08 | 1.06 | 0.31 |

*Reproductive parts (Flower + Siliqua): Details of treatments are given under materials and methods NS=Non-significant

**Table 4 : Effect of limited irrigation and nitrogen levels on periodical dry matter partitioning (g/plant) in different plant parts of Indian mustard**

| Treatments | At harvest | | | | | |
|---|---|---|---|---|---|---|
| | Leaf | | Stem | | Reproductive parts* | |
| | 1999-2000 | 2000-2001 | 1999-2000 | 2000-2001 | 1999-2000 | 2000-2001 |
| **Varieties** | | | | | | |
| $V_1$ | 1.65 | 1.62 | 15.87 | 14.63 | 22.04 | 21.93 |
| $V_2$ | 1.76 | 1.75 | 16.33 | 15.29 | 23.39 | 23.54 |
| C.D. (P=0.05) | 0.09 | 0.08 | 0.42 | 0.48 | 0.86 | 0.94 |
| **Irrigation schedule** | | | | | | |
| $I_0$ | 1.58 | 1.53 | 15.11 | 13.76 | 18.31 | 17.71 |
| $I_1$ | 1.87 | 1.85 | 17.14 | 16.20 | 27.40 | 28.24 |
| $I_2$ | 1.67 | 1.68 | 16.05 | 14.91 | 22.43 | 22.26 |
| C.D. (P=0.05) | 0.08 | 0.12 | 0.92 | 0.96 | 1.96 | 2.14 |
| **Nitrogen levels** | | | | | | |
| $N_0$-No nitrogen | 0.73 | 0.69 | 10.82 | 9.51 | 13.69 | 11.15 |
| $N_1$-40 kg N/ha | 1.13 | 1.16 | 13.55 | 12.58 | 18.55 | 17.96 |
| $N_2$-60 kg N/ha | 1.68 | 1.66 | 15.23 | 14.15 | 22.65 | 21.55 |
| $N_3$-80 kg N/ha | 1.81 | 1.91 | 17.37 | 16.12 | 24.23 | 23.55 |
| $N_4$-100 kg N/ha | 2.24 | 2.21 | 19.46 | 18.17 | 28.06 | 30.52 |
| $N_5$-120 kg N/ha | 2.64 | 2.49 | 20.17 | 18.92 | 29.11 | 31.59 |
| C.D (P=0.05) | 0.78 | 0.32 | 1.32 | 1.42 | 1.16 | 1.14 |

*Reproductive parts (Siliqua) NS=Non-significant

resulting in more vegetative growth. The present findings are in accordance with those of Lal *et al.* (2000).

**Dry matter partitioning:**

The data pertaining to dry matter accumulation in various plant parts *viz*., leaves, stems and reproductive parts (flower + siliqlua) are presented in Table 2, 3 and 4. Irrespective of years and treatments, the dry matter accumulation in leaves increased up to 90 DAS and decreased thereafter towards maturity, whereas dry matter in stems declined slightly after 120 DAS till maturity. However, dry matter accumulation in siliqua continued to increase from siliqua initiation till maturity during both the years of experimentation. At 30 DAS, different varieties did not show any significant variation in respect of dry matter accumulation in leaf and stem in any of the crop season. At 60 and 120 DAS, the variety Laxmi ($V_2$) recorded significantly higher leaves, stem and siliqua dry matter than the variety RH-9304 ($V_1$) during both the years. However, at 90 DAS, the variety Laxmi ($V_2$) produced significantly higher leaves, stems and siliqua than the variety RH-9304 ($V_1$) during 2000-2001 but the dry matter of stem did not vary markedly during 1999-2000. No. irrigation treatment was imposed during the crop stage (30 DAS) and hence no variation could be ascertained (Table 2). At 60 DAS, though total dry matter accumulation in leaves, stem and reproductive parts (flower buds + partially opened flowers) was higher in irrigated than unirrigated environment ($I_0$) but the variation was found to be non-significant both the years (Table 2). However at 90, 120 DAS and at maturity (harvest) irrigation level ($I_1$) recorded significantly higher leaves, stems and siliqua dry weight than $I_0$ and $I_2$ irrigation levels (Table 3 and 4). Irrigation level $I_2$ gave significantly higher leaves, stems and siliqua dry weight than $I_0$ level. This may be due to the fact that under no post sowing irrigated condition, there might be reduced photosynthesis, lower translocation and smaller sink capacity and moisture stress interference in sink-source movement and distribution.

Increasing nitrogen levels (Table 2, 3 and 4) at all growth stages increased dry matter production and higher partitioning to different plant organs was observed upto 120 kg N/ha ($N_5$) but at pat with 100 kg. N/ha ($N_4$) level. However, at 30 DAS, the nitrogen levels recorded significant variation in respect of leaf dry weight/plant while the variation in stem dry wt/plant was found to be non-significant during both the years of experimentation. The fertilized crop produced more dry matter and trans-located more to leaves and reproductive parts. Patil *et al.* (1997) also recorded higher growth of leaves, stems and siliqua during entire period till maturity with 120 kg N/ha.

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