Growth and yield of hybrid mustard as influenced by irrigation scheduling and nitrogen management

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Abstract
The field experiment entitled “Growth and yield of hybrid mustard as influenced by irrigation scheduling and nitrogen management” was conducted at the Central Research Farm, Bidhan Chandra Krishi Vishwavidyalaya, Mohanpur, West Bengal during *rabi* season (2017-18) in alluvial soil having medium soil fertility. It was conducted in split-plot design with three replications comprising 3-main plot irrigation scheduling treatments based in IW/CPE = 0.8, 1.0 & 1.2; and three sub-plot treatments of nitrogen @ 40, 80 & 120 kg/ha. The result of experiment revealed that the growth and yield of hybrid mustard crop was significantly influenced by both the main and sub-plot treatments. The maximum growth parameter like plant height, dry matter accumulation, CGR of hybrid mustard crop were recorded with IW/CPE=1.2 irrigation level and 120 kg N/ha. The yield attributes and yield also followed the similar trend, maximum yield was obtained with application of 120 kg N/ha under irrigation regime scheduled at IW/CPE=1.2. The yield variation due to irrigation regimes and nitrogen management was to the tune of 13.35 to 17.14% and 44.19 to 83.09%, respectively.

Keywords: Irrigation scheduling, nitrogen management, hybrid mustard, growth, yield

Introduction
Rapeseed mustard, have a significant role in Indian agriculture since almost each part of the plant is consumed either by human beings or animals depending upon the crop and its growth stage. Rapeseed-mustard crops in India include toria (*Brassica campestris L. var. toria*), brown sarson (*B. campestris L. brown sarson*), yellow sarson (*B. campestris L. var. yellow sarson*), Indian mustard (*B. juncea L. Czerny and cosson*), black mustard (*B. nigra*) and taramira (*Eruca sativa/vesicara Mill.*) species. Among them, Indian mustard is an important oilseed crop of the Indian subcontinent and contributes more than 80% of the total rapeseed-mustard production of the country. The oil content of Indian mustard varies between 30 to 45.7%. It is cultivated in an area of 5.96 million hectares with a production of 8.32 million tonnes yielding 1397 kg/ha (DOAC, 2018) [4]. In India, mustard is mainly grown in North West parts of India, Rajasthan and Uttar Pradesh are the major producing states in the country. In India, 85-90% of total rainfall is received during rainy season (July-September) and Indian mustard is grown during winter season (October-March) on conserved moisture (Ghosh et al. 2002)[6]. The major constraint attributing to low production of mustard are scarce and untimely water supply and poor fertility status of soil. Application of irrigation at regular interval with proper nutrient management is the other two most critical inputs which can substantially increase yield of mustard (Piri et al. 2011) [13]. But the irrigated mustard is generally confined to areas with limited amounts of irrigation water, which necessitates that efficient use of water should be achieved by following the best possible irrigation schedule. Yadav et al. (2010)[16] observed that water supply at the most critical growth stages (at flower initiation stage and silique development stage) achieved the maximum growth and yield attributes. However, better scientific irrigation scheduling like IW/CPE (irrigation water/ cumulative open pan evaporation) could be practiced to manage water efficiently. Nitrogen (N) is the most important nutrient, and being a protein, it is involved in several metabolic processes that strongly influence growth, productivity and quality of crops. Yield increases in Indian mustard at various locations in India have been reported with application of N as high as 150kg/ha or more (Rathore et al. 2014) [14]. But the nitrogen use efficiency is very low (30-40%) as it is lost...
from soil through volatilization, leaching and runoff. Hence the problem of low NUE further stress on better nitrogen management along with irrigation management. There is not much information on the effects of irrigation scheduling and nitrogen management and their interaction on growth and yield of mustard crop. Considering this, an attempt has been made here to gain a better understanding of the relationship between crop performance and water management and nitrogen metabolism. With this objective an experiment titled “Growth and yield of hybrid mustard as influenced by irrigation scheduling and nitrogen management” was planned.

Material and Methods
The field experiment was conducted at the Central Research Farm (22°56’ N latitude and 88°32’ E longitude and 9.75 meter above MSL), Gayespur, Nadia, under Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal during rabi season (2017-18) in alluvial soil having medium soil fertility (228 kg/ha total N, 30 kg/ha available P₂O₅, 198 kg/ha available K₂O, 0.58% Organic Carbon with pH 7.10). The experimental site is situated at the sub-tropical humid climate. The average annual rainfall is about 1500 mm and the mean temperature ranges from 27°C to 31°C. During the experimental period the maximum monthly temperature was achieved in December (32.48°C) and minimum monthly temperature was achieved in January (9.97°C). The total rainfall received was 71.10 mm throughout the cropping period. The field experiment was conducted in Split-Plot design with three replications comprising three main plot irrigation scheduling treatments based in IW/CPE (irrigation water/cumulative open pan evaporation ratio) = 0.8, 1.0 & 1.2; and three sub-plot treatments of Nitrogen @ 40, 80 & 120 kg/ha. Full dose of P₂O₅ (40 kg/ha), K₂O (40 kg/ha) and half dose of N (application rate as per treatment) was applied as basal doses and rest half of N was applied after 35 days. Sources of N, P₂O₅ and K₂O were Urea, SSP and MOP respectively. The experiment was conducted with a hybrid mustard variety named as PAN 70. A common irrigation was made here to gain a better understanding of the relationship between crop performance and water management and nitrogen uptake and translocation, higher photosynthetic activities which ultimately linked with the plant growth and development. The results are substantiated by the research findings of Piri and Sharma (2006), Dadhich et al. (2015) and Rathore et al. (2017) [10, 11, 13].

Among the nitrogen management treatments in sub-plots, the application of 120 kg N/ha recorded the highest plant height (155 cm) and dry matter accumulation (1041.7 g/m2) at harvesting stage. And least plant height (142 cm) and dry matter accumulation (579.4 g/m2) was observed with application of 40 kg N/ha. The variation in dry matter accumulation due to nitrogen doses was 42.74 to 79.79%. Highest CGR (15.6 g/m²/day) at 60-90 DAS was recorded with 120 kg N/ha followed by 80 kg N/ha (9.4 g/m²/day) and least was recorded with 40 kg N/ha (7.9 g/m²/day). The variation in Crop growth rate at 60-90 DAS due to nitrogen doses was 65.96 to 97.46%. Again application 120 kg N/ha resulted in highest number of branches (13.7) at harvesting stage which is followed by 80 kg N/ha (9.7) and 40 kg N/ha (8.2). Nitrogen supply to mustard improved the integrity of plant structure and the key physiological processes such as light interception by chlorophyll, energy for carbohydrate build-up and enhanced the hydraulic conductivity of the root cortical cells, thereby improving the growth parameters. (Dhawan, 2002; Namara et al. 2007) [3, 9].

Yield Attributes
Irrigation scheduling had marked effects on siliqua/plant, seeds/siliqua and thousand seed weight (Table 2). Application of irrigation at IW/CPE=1.2 recorded highest number of siliqua per plant (140) and seeds per siliqua (15). The variation in numbers of siliqua per plant and seeds per siliqua due to moisture regime was upto 11.90 to 19.44% and 6.38 to 15.38%, respectively. Enhanced water supply had resulted in a higher number of siliqua/plant, seeds/siliqua. However, highest test weight was reported from the irrigation scheduling treatment with IW/CPE=1 (3.7 g). Due to regular water supply at interval following irrigation scheduling, the crop did not suffer from water stress at reproductive stages and perhaps it facilitate better translocation of photosynthates for the formation of seed under irrigated treatments. These results were in agreement with the findings reported by Rana et al. (2019), Dash et al. (2013) and Ray et al. (2015) [12,2,13]. The yield attributes of mustard improved with the subsequent doses of N along with irrigation scheduling. Application of 120 kg N/ha resulted in highest number of siliqua per plant (190), seeds per siliqua (16.1) and test weight (3.9). Least

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response in this yield attributes were observed with application of 40 kg N/ha. During crop growth, supply of nutrients and availability of assimilates for pod set and seed filling are decisive factors affecting yield. For Indian mustard, the sink lies in the siliqua and seed and hence, under optimum supplies of N this greater translocation of photosynthates from leaf to siliqua resulting in robust siliqua and seeds (Hocking et al. 1997) [8]. Nitrogen stimulates plant growth by means of enlarged leaf canopy and a greater rate of leaf expansion, resulting in higher pods and higher seed number per pod possibly because of increased meristematic activity and development of more flowers and siliqua (Rathore et al. 2014) [14].

Seed Yield

The seed yield and biological of hybrid mustard crop was significantly influenced by irrigation and nitrogen management practices. The data on seed yield and biological yield substantiate this observation (Table 2). The maximum seed yield of 1606 kg/ha and maximum biological yield of 5470 kg/ha were recorded with IW/CPE=1.2. The least seed yield of 1371 kg/ha and least biological yield of 5282 kg/ha was noted in IW/CPE =0.8 irrigation schedule. Yield variation due to irrigation regimes was to the tune of 9.18 to 17.14%. The correlation study between yield attributes and seed yield revealed a high R² value ranging from 0.72 to 0.97 (Fig. 1), which indicate that increase in yield was largely attributed due to positive change in yield attributes. Moreover, adequate supply of moisture favourably improved nutrient uptake and translocation which ultimately increased the yield. The different levels of nitrogen doses applied in hybrid mustard crop had significant effect on seed yield with the variation of 26.98 to 83.09%. Among the nitrogen levels 120 kg/ha had recorded maximum seed yield of 1906 kg/ha followed by 80 kg/ha (1501 kg/ha). Similarly, the nitrogen levels of 120 kg/ha had recorded maximum biological yield of 6908 kg/ha followed by 80 kg/ha (5053 kg/ha). As mentioned earlier the higher availability of nitrogen to the mustard plant root during the crop season had augmented plant growth and further enhanced the yield attribute. These led to higher seed yield, which is also validated by the positive correlation between the yield attributes and yield data (Fig. 1).

Interaction effect of irrigation and nitrogen levels on seed yield of hybrid mustard crop was found significant (Table 3). The maximum yield of hybrid mustard 2016 kg/ha was achieved in IW/CPE=1.2 with 120 kg N/ha followed by the treatment IW/CPE=1 (1918 kg/ha) with the same dose of N/ha and the least yield was noted with the irrigation treatment of IW/CPE=1.2 with 40 kg N/ha. It was found that the enhanced moisture supply have increased the nitrogen availability to the plant throughout the crop growth, which finally resulted in high seed yield.

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### Table 1: Effect of irrigation schedules and nitrogen management on plant height, dry matter accumulation, CGR and number of branches of hybrid mustard

| Treatment | Plant height (cm) | Dry matter accumulation (g/m²) | CGR (g/m²/day) | No of branches |
|-----------|------------------|-------------------------------|---------------|---------------|
| Irrigation schedule (IW/CPE) | | | | |
| I1-0.8 | 146 | 771.0 | 10.8 | 11.2 |
| I2-1.0 | 148 | 706.2 | 9.2 | 9.7 |
| I3-1.2 | 150 | 873.6 | 12.9 | 10.8 |
| S. Em (+) | 2.44 | 23.40 | 0.25 | 0.24 |
| CD (P=0.05) | 7.80 | 63.69 | 1.01 | 1.00 |
| Nitrogen(Kg/ha) | | | | |
| N1 – 40 | 142 | 579.4 | 7.9 | 8.2 |
| N2- 80 | 147 | 729.8 | 9.4 | 9.7 |
| N3- 120 | 155 | 1541.7 | 20.2 | 13.7 |
| S. Em (+) | 2.63 | 21.82 | 0.23 | 0.16 |
| CD (P=0.05) | 7.12 | 61.11 | 0.72 | 0.51 |

### Table 2: Effect of irrigation scheduling and nitrogen management on yield attributes and yield of hybrid mustard

| Treatment | No of siliqua/plant | Seeds/siliqua | Test weight (g) | Biological yield (kg/ha) | Seed yield (kg/ha) |
|-----------|---------------------|---------------|-----------------|-------------------------|-------------------|
| Irrigation(IW/CPE) | | | | | |
| I1-0.8 | 125 | 13.0 | 3.4 | 5282 | 1371 |
| I2-1.0 | 117 | 14.1 | 3.7 | 5395 | 1471 |
| I3-1.2 | 140 | 15.0 | 3.6 | 5470 | 1606 |
| S. Em (+) | 2.54 | 0.10 | 0.04 | 57.2 | 44.8 |
| CD (P=0.05) | 6.88 | 0.41 | 0.018 | 143.1 | 112.32 |
| Nitrogen(Kg/ha) | | | | | |
| N1 – 40 | 87 | 12.0 | 3.2 | 4470 | 1041 |
| N2- 80 | 106 | 14.0 | 3.6 | 5053 | 1501 |
| N3- 120 | 189 | 16.1 | 4.0 | 6625 | 1906 |
| S. Em (+) | 2.11 | NS | 0.015 | 54.1 | 42.3 |
| CD (P=0.05) | 6.38 | NS | 0.046 | 140.3 | 108.11 |

### Table 3: Interaction effects of irrigation scheduling and nitrogen management on seed yield of hybrid mustard

| Nitrogen levels (kg /ha) | Seed yield (kg/ha) at different irrigation levels |
|--------------------------|-----------------------------------------------|
|                          | IW/CPE=0.8 | IW/CPE=1.0 | IW/CPE=1.2 | Mean |
| 40 | 1003 | 924 | 1198 | 1041 |
| 80 | 1327 | 1572 | 1603 | 1501 |
| 120 | 1783 | 1918 | 2016 | 1906 |
| Mean | 1371 | 1471 | 1606 | |

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Indian mustard (*Brassica juncea*) is an important edible oilseed crop in India. It is mainly grown under limited water availability conditions in semi-arid areas. Proper irrigation scheduling and N management can enhance the growth and development of mustard crop and increase its productivity. Based on our findings it was concluded that irrigation scheduling done at IW/CPE=1.2 along with application of 120 kg N/ha results in higher growth and yield in hybrid mustard.

**Fig 1:** Correlation between yields attributes and seed yield

| S.Em (±) | 44.8 | 42.3 | 53.12 | 52.02 |
|----------|------|------|-------|-------|
| CD (P=0.05) | 112.32 | 108.11 | 135.11 | 140.23 |

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