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NUTRIENT SOURCES AND PLACEMENT METHODS ON DRY MATTER ACCUMULATION AND YIELD OF INDIAN MUSTARD (*Brassica juncea* L.) UNDER EASTERN HIMALAYAN REGION

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ABSTRACT

The field experiment on nitrogen sources and placement methods on dry matter accumulation and yield of mustard (*Brassica juncea* L.) was conducted at Agricultural Research Farm, Rajiv Gandhi University, Itanagar, during *rabi* 2023-24. The experiment was laid in split-plot design and replicated thrice, wherein main plot consisted of three nitrogen sources *viz.* organic (1.2 t ha^{-1} vermicompost), 100% RDF (50:60:30 NPK kg ha^{-1}), and organic + chemical (50% vermicompost + 50% RDF), while sub-plot consisted of three placement methods; broadcasting, surface banding, and deep placement (10 cm depth). The results outlined that among the nitrogen sources, significantly higher dry matter accumulation was observed with 100% RDF at flowering (12.05 g plant^{-1}), maturity (15.33 g plant^{-1}) and post-anthesis (3278.1 mg plant^{-1}) stages. While for placement methods, deep placement recorded the highest dry matter. In addition, 100% RDF recorded highest value in yield attributes *viz*, branches plant^{-1} (10.78), siliqua plant^{-1} (99.0), and seeds siliqua^{-1} (10.34) which was on par with 50% vermicompost + 50% RDF, while deep placement resulted in maximum branches plant^{-1} (10.33), siliqua plant^{-1} (99.7), and seeds siliqua^{-1} (10.90). Subsequently, significantly higher grain yield was observed with 100% RDF which was 33.6% more than 100% vermicompost. While, deep placement resulted in 19.7% and 37% more than band placement and surface broadcasting, respectively. In addition, the highest benefit-cost ratio was with 100% RDF (2.5) and deep placement (2.6).

(Key words: Mustard, nitrogen, vermicompost, placement methods)

INTRODUCTION

Mustard (*Brassica juncea* L.), known by various names such as Rai, Raya, and Laha across different regions of India, holds a significant position within the cruciferae family. It is India's primary *rabi* oilseed crop with an acreage of approximately 80% of the total rapeseed-mustard in the country. India ranks as the world's third-largest producer of rapeseed-mustard after Canada and China contributing to 11% of worlds total production (Anonymous, 2023). Mustard alone constitutes nearly one-third (33%) of the total oilseed production in India, making it the second most important oilseed crop during the *rabi* season, cultivated under both rainfed and irrigated conditions. Indian mustard is nutritionally rich, with oil and protein content ranging from 37-49% and 20-25%, respectively (Kumar *et al*., 2017).

Oilseed production often faces challenges of annual yields variations due to imbalanced nutrient application and poor crop management. Hence, effective fertilizer management coupled with appropriate agronomic measures would plays a crucial role in augmenting mustard productivity, ensuring balanced plant nutrient supply. The use of organic nutrient solely or in conjunction with chemical fertilizers have been found to enhanced the soil fertility status apart from minimizing the negative impacts on the environment (Fayera and Alemayehu, 2021). Identifying key factors to enhance mustard production is essential, including improved varieties, proper irrigation, and the use of balanced fertilizers and placement methods. Indian soils often lack nitrogen, with low recovery rates, so implementing suitable placement methods can improve soil health and fertilizer efficiency (Mohan *et al*., 2015). In addition, the integrated use of organic and inorganics nutrient sources have been reported to enhanced the availability of both macro and micro-nutrients (Kaur *et al*., 2023). Placement methods *viz.,* surface band placement and deep placement of nitrogenous fertilizer offers multiple benefits, including improved crop stand, increased branching, and better economic returns compared to

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conventional broadcasting methods. To achieve the national goal of agricultural sustainability and food security, vertical diversification of agriculture in terms of more crops output from unit quantity of land through judicious use of fertilizer inputs especially N has special significance in modern agriculture. Further, the incorporation of organic nutrient sources have been found to enhance the growth and productivity of crops coupled with improved soil properties (Ezung *et al*., 2021). Majority of farmers in India broadcast nitrogen after seeding due to lesser labour cost and time saving. However, it results in inefficient utilization of nutrients that not only affects the yield but negatively impact the environment. Nitrogenous fertilizer can be easily deep-placed at sowing with a fertilizer drill and pora or can be applied in the form of narrow bands near the plant surface, which can significantly reduce the degree of fertilizers used and enhance its use efficiency. The efficiency of nitrogen use by most of the crop ranges from 20 to 40%. Therefore, proficient nitrogen management is essential in crop production systems for improving the long-term sustainability. Therefore, the current study was carried out to get better insights on nitrogen sources and placement methods on the growth and yield of mustard under rainfed hilly ecosystem of Eastern Himalayan region.

MATERIALS AND METHODS

The field experiment was conducted at the Agricultural Research Farm, Rajiv Gandhi University, Rono Hills, Doimukh during the *rabi* season of 2023-24. The experimental site located at 93°46'E latitude, 27°08'N longitude, and 350 m above mean sea level and falls under the 'Eastern Himalayan' region of the Agro-climatic zones of India. The region has a humid sub-tropical climate with hot, humid summers, and cold winters with an annual average rainfall of about 300 cm. During the experimental period, the highest temperature recorded was 32.6°C in April, while the lowest was 9.8°C in January. The initial soil chemical properties were analysed following the procedure of Jackson (1973) prior to commencement of the experiment in 2023, wherein the soil samples were collected from the depth of 0-15 cm using tube auger. The collected samples were air-dried, grounded, and sieved with 5 mm mesh and stored in a plastic container for further analysis. The initial soil pH, organic carbon, available nitrogen, phosphorus, and potassium were 4.76, 1.09%, 156.80 N kg ha^{-1}, 17.61 P_2O_5 and 350.11 K_2O kg ha^{-1} respectively. The experiment was laid out in a Split-Plot Design (SPD) with three replications, wherein main-plot consisted of three nitrogen sources *viz.* organic (1.2 t ha^{-1} vermicompost), RDF (50:60:30 NPK kg ha^{-1}), and organic + chemical (50% vermicompost + 50% RDF), while sub-plot consisted of three placement methods; broadcasting, band placement, and deep placement. The recommended fertilizer dose for rainfed hilly ecosystem of North East India is 50:60:30 NPK kg ha^{-1}. In organic and organic + chemical treatment plots, full dose of vermicompost was applied at final field preparation 10 days prior to sowing, while for chemical 50% nitrogen (urea) and full dose of phosphorus (SSP) and potassium (MOP) were applied at sowing. The remaining 50% nitrogen was top-dressed at 45 DAS (days after sowing). For broadcasting, the fertilizers were manually broadcast after final field layout, while for band placement the fertilizers were placed 5 cm away from seeds in band, and in deep placement fertilizers were placed at the depth of 10 cm below the surface and 5 cm away from the seeds. The mustard variety used was DMRIJ-31 and seeds were dibbled manually with a planting geometry of 30 cm x 10 cm and sown on 12th November, 2023.

The plant dry matter accumulation was recorded at flowering and maturity, wherein five random plants from each treatment were cut above the ground, sun-dried, and finally oven-dried at 60^{0}C to a constant weight. Further, the Post-anthesis dry matter accumulation (PDMA) was calculated as "total above-ground dry matter at maturity-total dry matter at flowering"; dry matter remobilization (DMR) as "total dry matter at flowering- vegetative dry matter at maturity"; and dry matter remobilization contribution to grain yield (DMRG) as " (DMR/grain yield) x 100". The yield attributing characters and yield of mustard *viz.,* plant height, number of branches plant^{-1}, siliqua plant^{-1}, seeds siliqua^{-1}, siliqua weight, test weight, seed yield, and stover yield were recorded at maturity from the net sampling plot after leaving two rows from each side. The data were statistically analysed for two-way ANOVA as given by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Dry matter accumulation

The significantly higher dry matter accumulation at flowering (12.05 g plant^{-1}) and maturity (15.33 g plant^{-1}) was observed with 100% RDF, while among the placement methods deep placement results in significantly higher dry matter accumulation both at flowering (11.17 g plant^{-1}) and maturity (14.78 g plant^{-1}), respectively. Further, the post-anthesis dry matter accumulation (PDMA) was highest with 100% RDF (3278.1 mg plant^{-1}) and deep placement (3602.4 mg plant^{-1}). In addition, there observed no significant difference among nitrogen sources for dry matter remobilization (DMR) and dry matter remobilization contribution to grain yield (DMRG), but among the placement methods significantly higher value was recorded with deep placement. There observed no significant difference among different treatment combinations except for PDMA and DMRG whereby 100% RDF in combination with deep placement resulted in maximum value. The higher dry matter accumulation at different stages of the crops with 100% RDF could be attributed to higher and easily available of nutrients with chemical fertilizers, resulting in better growth and development of the crops. In addition, deep placement might have reduced the loss of nitrogen in various form, thereby leading to greater and continue availability for the crops to uptake, which in turn gives higher accumulation of dry matter. Furthermore, the higher post-anthesis dry matter accumulation and remobilization positively correlates with the grain yield, wherein our results are in line with that of Huang *et al*. (2020), wherein they reported that higher dry matter accumulation at post-anthesis plays a greater role in increasing grain yield.

Table 1. Effect of nitrogen sources and placement methods on dry matter accumulation

Treatments	DMA at flowering (g plant^{-1})	DMA at maturity (g plant^{-1})	PDMA (mg plant^{-1})	DMR (mg plant^{-1})	DMRG (%)
Nitrogen sources					
100% Vermicompost	4.79	5.81	1019.80	1056.30	53.50
100% RDF	12.05	15.33	3278.10	2470.90	45.50
50% vermicompost + 50% RDF	8.61	11.27	2660.10	1698.50	44.30
SE(m)±	0.57	0.79	119.36	365.54	3.41
CD (p=0.05)	1.70	2.36	356.89	-	-
Placement methods					
Broadcasting	6.50	8.27	1768.90	1204.90	45.8
Band placement	7.77	9.36	1586.70	1861.00	54.9
Deep placement	11.17	14.78	3602.40	2159.60	42.6
SE(m)±	0.52	0.93	155.41	209.79	1.87
CD (p=0.05)	1.56	2.78	464.68	627.27	5.59
Nitrogen sources x Placement methods					
SE(m)±	0.99	1.37	206.73	633.14	5.91
CD (p=0.05)	-	-	618.12	-	17.67

* DMA= dry matter accumulation; PDMA= post-anthesis dry matter accumulation; DMR= dry matter remobilization; DMRG= dry matter remobilization contribution to grain yield

Yield

Nitrogen sources and placement methods had differential impacts on yield attributes and yield of mustard. The plant height (137.5 cm) was significantly highest with 100% RDF, while the number of branches plant^{-1}(10.78), siliqua plant^{-1} (99.0), and seeds siliqua^{-1} (10.34) were highest with 100% RDF, but at par with 50% vermicompost + 50% RDF. Subsequently, the weight of siliqua and test weight were maximum with 50% vermicompost + 50% RDF but remains at par with 100% RDF. Further, among the placement methods, deep placement resulted in significantly higher yield attributes *viz.,* plant height (140.9 cm), number of branches plant^{-1} (10.33), siliqua plant^{-1} (99.7), seeds siliqua^{-1} (10.90), and siliqua weight (0.69). In addition, grain yield (1.19 t ha^{-1}) was highest with 100% RDF, whereby it was significantly more than 100% vermicompost to the tune of 33.6%, but

Table 2. Effect of nitrogen sources and placement methods on yield attributing characters and yield of mustard

Treatments	Plant height (cm)	Branches plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Seeds siliqua^{-1} (no.)	Weight of siliqua (g)	Test weight (g)	Stover yield (t ha^{-1})	Seed yield (t ha^{-1})	B:C ratio
Nitrogen sources									
100% Vermicompost	117.60	7.00	75.30	9.28	0.38	4.46	1.52	0.79	1.2
100% RDF	137.50	10.78	99.00	10.34	0.53	5.27	1.99	1.19	2.5
50% Vermicompost + 50% RDF	121.70	10.56	87.80	9.70	0.54	5.52	1.84	1.11	2.1
SE(m)±	2.25	0.52	3.85	0.23	0.02	0.04	0.17	0.04	-
CD (p=0.05)	6.73	1.56	11.51	-	0.06	0.12	-	0.12	-
Placement methods									
Broadcasting	108.90	8.33	76.20	8.71	0.29	5.02	1.43	0.80	1.3
Band placement	127.10	9.67	86.20	9.72	0.47	5.08	1.88	1.02	1.9
Deep placement	140.90	10.33	99.70	10.90	0.69	5.16	2.05	1.27	2.6
SE(m)±	2.36	0.34	2.77	0.32	0.01	0.07	0.16	0.03	-
CD(p=0.05)	7.06	1.02	8.28	0.96	0.03	-	-	0.09	-
Nitrogen sources x Placement methods									
SE(m)±	3.90	0.90	6.66	0.41	0.04	0.08	0.30	0.08	-
CD (p=0.05)	11.66	-	-	-	0.12	-	-	-	-

stover yield remained similar among the nitrogen sources. Similarly, significantly higher grain yield (1.27 t ha^{-1}) was noted under deep placement which was 19.7% and 37% more than broadcasting and band placement respectively, while stover yield was at par among the placement methods. There observed no significant interaction effect except plant height and weight of siliqua wherein maximum value was recorded when 100% RDF was deep placed. The higher yield attributes with 100% RDF could be the result of increased nutrient availability, leading to better growth and more efficient translocation of photosynthates from source to sink (Tripathi *et al.,* 2010). Further, the combined application of vermicompost and fertilizer might have enhances the growth and facilitates the transport of photosynthates to reproductive structures, thereby increasing the weight of siliqua $plant^{-1}$ and test weight (Singh and Pal, 2011). The significant increase in yield of mustard with the 100% RDF could be attributed to enhancements in yield-related traits coupled with greater dry matter accumulation, increased plant height, and profuse branching. Our results are in line with that of Babar and Dongale (2011) and Roul *et al.* (2005), wherein they reported higher yield with 100% RDF. Furthermore, the benefit-cost ratio was highest with 100% RDF (2.5) and deep placement (2.6) respectively, which could be attributed to higher grain yield as the nutrients were easily available to the plants for its uptake. Thus, the present study inferred that proper adoption of RDF coupled with placing of fertilizer below the soil of about 10 cm depth could be a sustainable option for enhancing the yield of mustard under hilly agroecosystem of North-Eastern India.

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