Journal of Crop and Weed, 17(3): 35-40 (2021)

ISSN- O : 2349 9400 ; P : 0974 6315

http://cwssbckv.org
www.cropandweed.com

Growth and yield of hybrid mustard (*Brassica juncea* L.) as influenced by foliar nutrition in Gangetic plains of West Bengal

A. SARKAR, *K. JANA AND R. MONDAL

Department of Agronomy,
Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya,
Mohanpur- 741252, Nadia, West Bengal, India

Received : 18.06.2021 ; Revised : 24.07.2021 ; Accepted : 31.07.2021

DOI: https://doi.org/10.22271/09746315.2021.v17.i3.1488

ABSTRACT

A field experiment was conducted to study the effect of foliar nutrition on hybrid mustard var. Kesari-5111 during rabi seasons of 2018-19 and 2019-20 at Instructional Farm, BCKV, Jaguli, Nadia (West Bengal). Results revealed that mustard plot fertilized with recommended dose of chemical fertilizer (RDF) along with the foliar application of di-ammonium phosphate (DAP)at2% recorded the highest plant height, leaf area index, dry matter accumulation and number of siliqua plant^{-1}, number of seeds siliqua^{-1}. Different foliar nutrition significantly improved the seed yield of hybrid mustard by 15.8 to 81.3% over control plot. The maximum seed yield of hybrid mustard was recorded as1971 kg ha^{-1} with DAP @ 2% followed by sulphur @ 0.5% obtaining seed yield of 1867 kg ha^{-1}. Among the foliar spray treatments, highest oil content (39.9%)was recorded with sulphur at 0.5% followed by Boron (Borax) at 0.1%, recording 38.7% oil content. Based on the experimental results,it may be recommended that an integration of recommended dose of chemical fertilizer (RDF) along with either foliar application of DAP at 2% or Urea at 2% or Sulphur at 0.5% enhanced the growth and yield of hybrid mustard as well as improved the soil nutrient status in Gangetic alluvial soil of West Bengal.

Keywords: Foliar nutrition, hybrid mustard, yield, oil percentage, soil nutrient status

India is the fourth biggest oilseed economy in the world. European Union is the dominant producer of mustard seed in the world accounting for 35% of the world production followed by China (22%), Canada (21%) and India (11%) (GOI, 2018). In India, mustard is the second most popular edible oilseed after groundnut, sharing 27.8% in the India's oilseed economy. Total production of rapeseed-mustard in India was 7.9 million tones with average productivity of 1,088 kg ha^{-1}(AICRP on Rapeseed-Mustard, 2016), which needs to be enhanced up to 2562 kg ha^{-1} by 2030 for ensuring edible oil for attaining self-sufficiency (ICAR-DRMR, 2011). The productivity of mustard crop in West Bengal (1194 kg ha^{-1}) is less than developed countries mainly due to poor environmental conditions and lack of proper agronomic management. It is mostly cultivated for edible oils but also possesses varied uses as spices, condiment, leafy vegetable and forage-fodder for livestock (Jakhar *et al*., 2018). During its life cycle, crop can be exposed to different degrees of water and nutrient stress. Long term trend analysis data of this region shows that the crop would face adverse effect of heat stress when sown late condition (Kumari *et al*., 2019). Foliar application of major as well as micronutrients helps in the rapid translocation of nutrients when compared to soil application which is very pertinent in mitigating stress in plants. Foliar spray technique supports the nutrients to compass the site of food synthesis directly, leading no wastage and immediate supply of food and thereby reduce the requirement of fertilizers (Das and Jana, 2015). Instead of soil application, foliar fertilization may be the best fit for alleviating of the nutrient deficiencies with special emphasis on nitrogen deficit under moisture stress condition (Banerjee *et al*., 2019). Micronutrient application of sulphur was reported to increase the yield attributes and yield of Indian mustard, and also had significant effect on oil quantity and quality of mustard (Ray *et al*., 2015). Zinc (Zn) is one of the important micronutrient particularly in our country because most of Indian soils are deficient in Zn. Zinc is directly or indirectly required by several enzyme systems and is closely involved in the nitrogen metabolism. It is also constituent of many enzymes and proteins in plant body (Mondal *et al*., 2020). Boron (B) is also an important constituent of cell walls and is involved in translocation of photosynthates. It also helps in pollen viability and pollen tube development (Jana *et al*., 2020). Not only the foliar application of micronutrient but also foliar application of hormones gives better results in yield and quality of different crop plants. Salicylic acid is a growth regulator as well as phenolicphy to hormone and is found in plants playing key roles in plant growth and development, photosynthesis, transpiration, ion uptake and transport mediating in plant protective role of pathogenic pathogens. Therefore, the present investigation was

Email: kjanarrs@gmail.com

carried out to adjudge the effect of foliar nutrition on growth, yield attributes and seed yield of hybrid mustard var. Kesari-5111 under Gangetic alluvial soil of West Bengal.

MATERIALS AND METHODS

The field experiment was carried out during the *rabi* (winter) seasons of 2018-19 and 2019-20 at the Instructional Farm (22°93' N latitude, 88°53' E longitude and 9.75 m above mean sea level) of Bidhan Chandra KrishiViswavidyalaya, Nadia, West Bengal in medium land situation under tropical climate. The average rainfall was 1440 mm, 75% of which was received during June to September period. The soil of the experimental field was sandy loam in texture having bulk density 1.48 gcc^{-1}, soil moisture content at FC and PWP were 24.6 and 11.4%, respectively. The experimental soil was neutral in reaction (pH 6.68), having soil organic carbon 0.54%, available N 196.4 kg ha^{-1}, P_2O_5 29.2 kg ha^{-1} and K_2O 192.1 kg ha^{-1}. Meteorological data pertaining to the cropping seasons revealed that maximum temperature ranged between 23.34°C to 33.99°C, and minimum temperature prevailed between 9.97°C to 18.04°C. The maximum and minimum relative humidity ranged between 94.06 to 97.21% and 44.93 to 59.56%, respectively. The experiment was laid out in randomized complete block design (RCBD) with three replications comprising of nine foliar nutrition treatments viz. T_1- No foliar spray (Control-1);T_2- Water spray (Control-2); T_3- Urea (46%N) at 2% (20 g $litre^{-1}$ of water); T_4-DAP (NPK-18:46:0) at 2% (20 g $litre^{-1}$ of water); T_5- Water soluable sulphur at 0.5% (5 g litre-1 of water); T_6-NPK (grade 19 : 19 :19) at1% (10 g $litre^{-1}$ of water) ;T_7- Zinc (in form of $ZnSO_4$) at 0.2% (2 g $litre^{-1}$ of water); T_8- Boron (in form of Borax) at 0.1% (1 g $litre^{-1}$ of water); T_9- Salicylic acid 100 ppm. The seeds of mustard hybrid var. 'Kesari-5111' were sown at 30 cm (row to row)× 10 cm (plant to plant) spacing in the plots of size 5m × 4m. Seeds were dibbled manually at a depth of 2-3 cm below the soil surface with the help of hand tynes and were covered properly with soils. Nitrogen, phosphorus and potassium at100, 50 and 50 kg ha^{-1} in the form of urea, single super phosphate and muriate of potash, respectively across all treatment was considered as recommended dose of fertilizer (RDF). Half (½th) of total recommended N along with full recommended P_2O_5 and K_2O were applied as basal (during final land preparation). Remaining ½ N was applied at 30 days after sowing (DAS). The foliar application was done at pre-flowering and siliqua initiation stage at 45 and 60 DAS, respectively. All the plots were separated by about 15 cm ridges. Water to each plot was uniformly applied from irrigation channel. Plant protection measures (control of weeds, insects and diseases) were takenas and when required by the crop. Observations were recorded on growth parameters viz. plant height, dry matter accumulation, crop growth rate, numbers of primary branches $plant^{-1}$, leaf area index (LAI). Observations and data were recorded on yield attributes viz. numbers of siliquae $plant^{-1}$, numbers of seeds $siliqua^{-1}$, test weight, seed yield, harvest index (HI), and qualitative traits,viz.oil recovery and soil nutrient available status (N, P and K). All the data were statistically analysed by OPSTAT(online statistical analysis tool) and also pooled analysis of two years' data was done. Principal component analysis (PCA)was performed using XLSTATv. 2021 software to exhibit the correlation between the various parameters and their relationship with the different treatments.

RESULTS AND DISCUSSION

Crop growth characters

Crop growth in terms of plant height increased as the age of the crop progressed towards maturity, irrespective of different foliar nutrition. Among the different foliar application schedules, application of DAP at 2% recorded the tallest plant height (179.2 cm) at the time of harvest, followed by foliar application of urea at 2%. The lowest plant height (110.6 cm)was obtained at no foliar spray (Table 1). The experimental results revealed that plant height of hybrid mustard was significantly influenced by the foliar nutrition management practices. This might be due to application of DAP and urea, helps in nutrient acquisition by acting as chemical catalyst in plants for enhancing vegetative growth of plant. The results are in agreement with the findings of Jaiswal *et al*. (2015) where they reported that the plant height of mustard was significantly influenced by the foliar application of phosphorus and nitrogen.The leaf area index (LAI) at all the growth stages of hybrid mustard was significantly affected by foliar nutrition levels (Table 1). At 90 DAS, the highest LAI (3.49) was obtained with foliar spray of urea at 2%, and lowest LAI (1.82) was obtained at no foliar spray. These results are in conformity with the findings of Kaur *et al*.(2019) where they reported that the higher doses of nitrogen fertilizer lead to a higher LAI. Dry matter accumulation varied with different foliar nutrition management (Table 1). Among all the treatments, highest dry matter accumulation (673.1gm^{-2}) has been recorded with DAP at 2% (20g $litre^{-1}$ of water), and it was followed by foliar application of urea at 2% (recording 658.8 g dry matter m^{-2}), and the lowest value of dry matter accumulation (512.3 gm^{-2}) was obtained at no foliar spray treatment. The dry matter accumulation shows the best result with foliar spray of DAP at 2% as

compared to urea at 2% due to presence of nitrogen and phosphorus helps in better growth and development of crop. The results are in agreement with Rana *et al*. (2018). In the present experiment, the rate of growth for hybrid mustard (var. Kesari- 5111), as measured by calculating crop growth rate (CGR), reached at top level during 60-90 DAS, and beyond that it showed a decreasing trend towards maturity. The CGR of tested hybrid mustard cultivar was significantly influenced by the different types of foliar nutrition (Table 1) and the highest CGR during 60-90 DAS was recorded with DAP at 2%, followed by Urea at 2%, recording results of 12.7 gm^{-2} day^{-1} and 10.8 gm^{-2} day^{-1}, respectively, and the values are statistically at par. On contrary, control

Table 1: Effect of foliar nutrition on growth parameters of hybrid mustard (Pooled data of 2 years)

Treatments	Growth parameters			
	Plant height at harvest (cm)	Leaf area index (at 90 DAS)	Dry matter production at harvest (g m^{-2})	Crop growth rate (at 60-90 DAS) (gm^{-2} day^{-1})
T_1	110.6	1.82	512.3	8.6
T_2	117.8	2.34	537.7	10.5
T_3	172.1	3.49	658.8	10.8
T_4	179.2	3.37	673.1	12.7
T_5	145.3	3.01	553.6	10.7
T_6	149.7	3.31	657.1	10.5
T_7	139.5	3.02	576.0	9.5
T_8	146.2	2.94	638.0	10.2
T_9	166.9	2.68	541.0	9.6
SEm (±)	**9.36**	**0.11**	**8.15**	**0.09**
LSD (0.05)	**27.2**	**0.33**	**23.83**	**0.28**

T_1- No foliar spray; T_2- Water Spray; T_3- Urea @ 2% (20 g $litre^{-1}$of water); T_4- DAP @ 2% (20 g $litre^{-1}$ of water); T_5- Water soluable sulphur @0.5% (5 g $litre^{-1}$of water); T_6- NPK (19:19: 19) @ 1% (10 g $litre^{-1}$of water); T_7- Zinc ($ZnSO_4$) @ 0.2 % (2 g $litre^{-1}$ of water); T_8-Boron (Borax) @ 0.1 % (1 g $litre^{-1}$of water); T_9- Salicylic acid 100 ppm (100 mg $litre^{-1}$ of water)

plots received without any foliar application (T_1) exhibited less value of CGR.

Yield attributes and yield

Application of foliar nutrition enhanced the yield attributes and seed yield of hybrid mustard during winter season, compared to control situation (Table 2). The number of primary branches per plant was significantly influenced by various foliar nutrition treatments. Under different treatments of foliar nutrition, the best result was found with the application of urea at 2% which showed the highest branches per plant (10.7), followed by DAP at 2% (recording 10.2 numbers of primary branches per plant).The lowest number of primary branches per plant (4.9) was recorded from control treatment. Under different foliar application protocols, the maximum number of siliqua per plant (242.1) was obtained with DAP at 2% followed by urea at 2% (222.1) applied plot. The lowest number of siliqua per plant was recorded from no foliar treatment (137.1). The number of seeds per siliqua was significantly influenced by the different foliar nutrition treatments. Highest number of seeds per siliqua (11.8) was recorded in the plot where foliar application of Borax at 0.1% was done, it was statistically at par with the application of DAP at 2%. The lowest number of seeds per siliqua (7.9) was obtained from control plot (no foliar spray). The test weight was not significantly influenced by different foliar nutrition treatments. However, in this experiment the highest value of test weight (4.2 g) was obtained with application of borax at 0.1% followed by NPK-19:19:19 at 1% (recording 4.1 g test weight). The lowest value of test weight was recorded at no foliar spray. Test weight of hybrid mustard was non-significant as it is a genetically governed character. The seed yield of hybrid mustard was significantly influenced by the diverse foliar nutrition practices in the new alluvial soils of West Bengal and the application of different combination of macro and micro-nutrients in hybrid mustard had resulted significant seed yield variation of hybrid mustard var. Kesari-5111ranging from 1087 to 1971 kg ha^{-1}. The yield increase was to tune of 15.80 to 81.32% over control (no foliar spray). In this experiment, the highest seed yield (1971kg ha^{-1}) was recorded in the treatment where application of DAP at 2% followed by sulphur at 0.5% (obtaining the seed yield of 1867kg ha^{-1}). A good seed yield of 1705 kg ha^{-1} was also obtained

Table 2: Effect of foliar nutrition on yield attributes and seed yield of hybrid mustard (Pooled data of 2 years)

Treatments	Yield attributes and yield							
	No. of primary branches plant^{-1}	No. of siliqua plant^{-1}	No. of seeds siliqua^{-1}	Test weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Oil content (%)
T_1	4.9	137.1	7.9	3.5	1087	1875	34.49	33.7
T_2	5.2	150.7	8.2	3.7	1143	2145	34.77	35.3
T_3	10.7	222.1	10.9	3.6	1740	4215	29.23	36.2
T_4	10.2	242.1	11.2	3.7	1971	4567	30.15	35.5
T_5	6.9	193.7	9.6	3.8	1867	4349	30.04	39.9
T_6	8.7	215.7	10.1	4.1	1680	3949	29.84	37.2
T_7	6.7	177.3	9.1	3.9	1568	2978	34.50	38.5
T_8	7.7	209.5	11.8	4.2	1705	3517	32.66	38.7
T_9	6.2	165.1	8.8	3.8	1243	2743	31.19	37.6
SEm (±)	**0.33**	**5.21**	**0.24**	**0.46**	**56.65**	**91.52**	**1.55**	**0.39**
LSD (0.05)	**0.97**	**15.13**	**0.71**	**NS**	**164.66**	**274.56**	**4.51**	**1.13**

T_1-No foliar spray; T_2- Water Spray; T_3- Urea @ 2% (20 g litre^{-1} of water); T_4- DAP @ 2% (20 g litre^{-1} of water); T_5- Water soluable sulphur @0.5% (5 g litre^{-1} of water); T_6- NPK (19:19: 19) @ 1% (10 g litre^{-1} of water); T_7- Zinc ($ZnSO_4$) @ 0.2 % (2 g litre^{-1}of water); T_8- Boron (Borax) @ 0.1 % (1 g litre^{-1} of water); T_9- Salicylic acid 100 ppm (100 mg litre^{-1} of water)

with foliar application of boron (borax) at 0.1 %. Adequate crop nutrition improves vegetative and reproductive growth, as was evident from taller and vigorous plants having wider leaf surface, more dry matter accumulation, and thus the plant can attain a greater number of siliqua plant^{-1}, seeds siliquae^{-1} and yield contributing parameters and ultimately the seed yield (Mondal *et al.*, 2018). Stover yield of hybrid mustard was found best result with DAP at 2% (recording stover yield of 4567 kg ha^{-1}), which was statistically at par with sulphur at 0.5% spray (4349kg ha^{-1}). The lowest stover yield (1875 kg ha^{-1}) was recorded from control *i.e.* no foliar spray. In addition, harvest Index (HI)was significantly different among the treatments. Harvest Index of hybrid mustard was found highest (34.50%) in plots receiving foliar application of zinc at 0.2%, followed by in control treatment (HI 34.49%). Foliar spray of nutrient significantly influenced oil percentage. Among the foliar spray, oil percentage was recorded highest (39.9%) with sulphur at 0.5% followed by boron (borax) at 0.1% (38.7% oil percentage), and lowest oil content (33.7%) was obtained with no foliar spray treatment. Sulphur application might have enhanced metabolic activity and photosynthetic rate due to its involvement in chlorophyll formation, enzyme activation as well as primary and secondary metabolism, and thus, ultimately increased the oil quantity (Rana *et al.*, 2020).

Principal component analysis (PCA)

In the present study, PCA of the different parameters comprised of two principal components (PC1 and PC2) explained 88.89% of the total variation in the experiment. PC1 explained 77.27% and PC2 explained 12.62% of the total variation. A strong correlation was observed between components, *viz.*seed yield, plant height, dry matter production, leaf area index, number of primary branches, number of siliquae plant^{-1}, number of seeds siliquae^{-1}, and test weight. Conjunctional of 9 treatments on hybrid mustard yield and yield attributes revealed that combination of RDF and foliar spray of DAP @ 2% on 'Kesari 5111[1] produced highest values for the given parameters and showed significant correlation with these attributes (Fig. 1) in addition to the application of RDF with foliar spray of sulphur @ 0.5% recorded significant result.

Nutrient status

After harvesting of crops, available soil nitrogen, phosphorus and potassium varied significantly with different foliar nutrition management practices (Table 3). However, significantly higher available nitrogen (203.1 kg ha^{-1}) was recorded with foliar application of urea at 2% followed by NPK (19:19:19) at 1% (198.8 kg ha^{-1}). Highest soil available phosphorus (37.2 kg

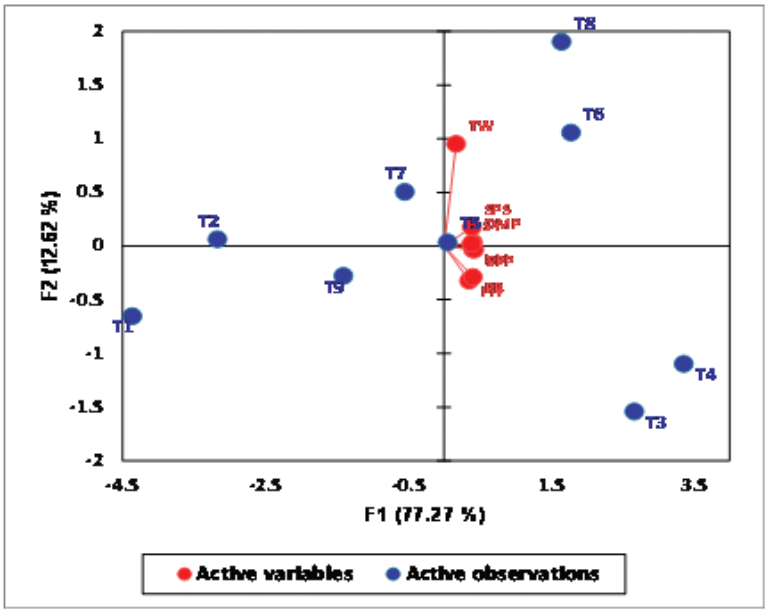

Fig. 1: PCA graphs of 9 treatments for yield, yield attributes and agronomic traits of the experiment. PH = plant height; DMP = dry matter production; LAI = leaf area index; PB = number of primary branches plant^{-1}; SPP = number of siliquae plant^{-1}; SPS = number of seeds siliquae^{-1}; TW = 1000-seed weight; SY = seed yield; T_1-No foliar spray; T_2- Water Spray; T_3- Urea @ 2% (20 g litre^{-1}of water); T_4 - DAP @ 2% (20 g litre^{-1}of water); T_5- Water soluble sulphur @0.5% (5 g litre^{-1}of water); T_6- NPK (19:19:19) @ 1% (10 g litre^{-1}of water); T_7- Zinc ($ZnSO_4$) @ 0.2 % (2 g litre^{-1}of water); T_8-Boron (Borax) @ 0.1 % (1 g litre^{-1}of water); T_9- Salicylic acid 100 ppm (100 mg litre^{-1} of water)

Table 3: Effect of foliar nutrition on soil nutrient status after experimentation

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1	189.3	30.1	202.2
T_2	193.1	35.9	209.3
T_3	203.1	32.7	208.3
T_4	195.8	37.2	203.5
T_5	196.4	31.8	204.8
T_6	198.8	36.1	210.7
T_7	195.4	34.2	209.5
T_8	192.3	30.2	210.5
T_9	189.2	31.6	209.1
SEm (±)	**1.78**	**0.62**	**3.02**
LSD (0.05)	**5.64**	**1.86**	**NS**

T_1-No foliar spray; T_2- Water Spray; T_3- Urea @ 2% (20 g litre^{-1}of water); T_4- DAP @ 2% (20 g litre^{-1}of water); T_5- Water soluable sulphur @0.5% (5 g litre^{-1}of water); T_6- NPK (19:19:19) @ 1% (10 g litre^{-1}of water); T_7- Zinc ($ZnSO_4$) @ 0.2 % (2 g litre^{-1}of water); T_8- Boron (Borax) @ 0.1 % (1 g litre^{-1}of water); T_9- Salicylic acid 100 ppm(100mg litre^{-1} of water)

ha^{-1}) was recorded in DAP at 2% applied plots and highest available potassium (210.7 kg ha^{-1}) was recorded with NPK-19:19:19 at 1% fertilized plots.

CONCLUSION

Conclusively, application of foliar nutrition was found to be superior for enhancing growth and yield of hybrid mustard (var. Kesari- 5111). Among the foliar nutrition treatments, application of DAP at 2% and Sulphur at 0.5% in conjunction with RDF (N, P_2O_5 and K_2O at 100, 50 and 50 kg ha^{-1}) were found to be more beneficial in terms of growth and seed yield. Hence, we suggest an integration of RDF (N, P_2O_5 and K_2O @ 100, 50 and 50 kg ha^{-1}) with either foliar application of DAP @ 2% (20 g litre^{-1}of water) or sulphur @ 0.5% (5 g litre^{-1}of water) at pre-flowering and siliqua initiation stages (at 45 and 60 DAS), respectively not only to

augment growth and seed yield of hybrid mustard but also to improve soil nutrient status in Gangetic alluvial soil of West Bengal.

REFERENCES

AICRP (Rapeseed–Mustard). 2016. *Annual Progress Report*. Directorate of Rapeseed–Mustard Research, Sewar, Bharatpur, Rajasthan.

Banerjee, P., Kumari, V.V., Nath, R. and Bandyopadhyay, P. 2019. Seed priming and foliar nutrition studies on relay grass pea after winter rice in lower Gangetic plain. *J. Crop and Weed*., **15(3)**: 72-78.

Das, S.K. and Jana, K. 2015. Effect of foliar spray of water soluble fertilizer at pre flowering stage on yield of pulses. *Agric. Sci. Digest*, **35(4)**: 275- 279.

DRMR. 2011.Vision 2030. Directorate of Rapeseed-Mustard Research, Bharatpur, 321-303, Rajasthan:30

GOI. 2018. Agricultural Statistics at a Glance. Agricultural Statistics Division, Department of Agriculture and Cooperation and Farmers Welfare, Ministry of Agriculture, GOI, New Delhi.

Jaiswal, A.D., Singh, S.K., Singh, Y.K., Singh, S. and Yadav, S.N. 2015. Effect of sulphur and boron on yield and quality of mustard (*Brassica juncea* L.) grown on Vindhyan red soil. *Journal of the Indian Society of Soil Science*, **63(3)**: 362-364.

Jakhar, P., Rana, K.S., Dass, A., Choudhary, A.K., Kumar, P., Meena, C. M. and Choudhary, M. 2018. Tillage and residue retention effect on crop and water productivity of Indian mustard (*Brassica juncea*) under rainfed conditions. *Indian J Agric Sci.*, **88**: 47-53.

Jana, K., Mondal, R. and Mallick, G.K. 2020.Growth, productivity and nutrient uptake of aerobic rice (*Oryza sativa* L.) as influenced by different nutrient management practices.*Oryza- An International Journal on Rice*, **57**(1): 49-56.

Kaur, M., Kumar, S.and Kaur, A. 2019.Effect of foliar application of nitrogen, phosphorus and sulphur on growth and yield of Gobhi Sarson (*Brassica napus* L.) in central Punjab. *Journal of Oilseed Brassica*, **10**(1): 47-50.

Kumari, V.V., Banerjee, P., Nath, R., Sengupta, K., Chandran, M.A.S. and Kumar, R. 2019. Effect of foliar spray on phenology and yield of Lentil sown on different dates. *J. Crop and Weed.*, **15**(3): 54-58.

Mondal, M.M.A., Malek, M.A. and Bhuiyan, M.S.H. 2018. The role of morpho-physiological attributes on the seed yield of *Brassica juncea*. *Acta Scientific Agriculture*.,**2**(5): 22-26.

Mondal, R., Goswami, S., Goswami, S.B. and Jana, K. 2020.Effect of different nutrient management practices on growth, grain yield, production economics, soil nutrient availability of transplanted *kharif* rice (*Oryza sativa*. L) and correlation studies. *J. Crop and Weed*.,**16**(1): 172-179

Rana, D. S., Dass, A., Rajanna, G. A.and Choudhary, A. K. 2018. Fertilizer phosphorus solubility effects on Indian mustard–maize and wheat–soybean cropping systems productivity. *Agronomy Journal.*, **110**(6): 2608-2618.

Rana, K., Parihar, M., Singh, J.P. and Singh, R.K. 2020. Effect of sulfur fertilization, varieties and irrigation scheduling on growth, yield, and heat utilization efficiency of Indian mustard (*Brassica juncea* L.). *Communications in soil science and plant analysis*, **51**(2): 265-275.

Ray, K., Sengupta, K., Pal, A.K. and Banerjee, H. 2015. Effects of sulphur fertilization on yield, S uptake and quality of Indian mustard under varied irrigation regimes. *Plant, Soil and Environment*, **61**(1): 6-10.