Biological Forum – An International Journal **14(3): 1385-1390(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effect of Novel Sources of Nutrients, their Dose and Mode of Application on Yield, quality and Profitability of Indian Mustard [*Brassica juncea* (L.) Czern & Coss]

***Sandeep Kumar Verma*[1]*, *N.S. Rana*[2], *Vivek*[2], *B.P. Dhyani*[3], *Bhim Singh*[4], *Aparna Verma*[1] *and Durgesh Kumar Maurya*[1]**

[1]*M. Sc. Scholar, Department of Agronomy,*
Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh), India.
[2]*Professor, Department of Agronomy,*
Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh), India.
[3]*Professor, Department of Soil Science & Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh), India.*
[5]*Associate Professor, Statistics, Basic Science,*
Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh), India.

(Corresponding author: Sandeep Kumar Verma)*
(Received 15 July 2022, Accepted 22 August, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: In order to evaluate the "Effect of novel sources of nutrients, their dose and mode of application on yield, quality and profitability of indian mustard [*Brassica juncea* (L.) Czern & Coss]" the investigation was carried out on well drained sandy clay loam soil, low in organic carbon and available nitrogen, medium in available phosphorus, potassium, sulphur and zinc and moderately alkaline in pH during 2020-21 at crop research centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.). Novel nutrient sources and their modes of applications with 12 treatments consisting of control, basal application of recommended dose 100% NPK & S (120:40:40:20), 75% NPK&S (90:30:30:15) + NPK (18:18:18) 0.5% spray + NPK Consortia (seed treatment 50 ml in 0.6 litre water for 6 kg seed) + Bio-stimulant (625 ml ha^{-1}) + Nano N (4 ml l^{-1}) + Nano Zn (10 ml l^{-1}) + zinc sulphate 5 kg ha^{-1} in various combinations were attempted on mustard variety Pusa Vijay in RBD with three replications.
The results of the study revealed that mustard grown with 100% NPK & S + Nano Zn spray attainted significantly maximum grain yield (24.9 q ha^{-1}), stover yield (113.8 q ha^{-1}) and biological yield (138.6 q ha^{-1}) which was increased by 33.87%, 64.2% and 57.67% as compared to recommended dose of fertilizers respectively. The highest oil content (39.2%) and oil yield (976.1 kg ha^{-1}) was also recorded with 100% NPK & S + Nano Zn spray. Thus, the mustard crop grown with application of 100 % NPK&S + nano Zn sprayhad attained maximum yield (grain, stover and biological), oil content and yield, fetched higher net returns with higher B:C ratio.

Keywords: Nano fertilizers, Bio stimulants, NPK consortia, NPK (18:18:18), profitability and Indian mustard.

INTRODUCTION

Rapeseed and mustard are 3rd important edible oil seed crops of India next to groundnut and soybean. India has 12-15% of the world's area under oilseed but account for less than 6-7 % of world's production to meet the need of about 17% of world population. Total area, production and productivity of rapeseed-mustard in world during 2020-21 were 36.12 million hectares (mha), 72.29 million metric tonnes (mmt) and 2000 kg ha^{-1}, respectively. India ranked 2nd in terms of area after Canada and 4th position in term of production after Canada, European Union and China under rapeseed and mustard in the world with 8.20 (mha) area, 10.4 (mt) production and producing an average of 1040 kg ha^{-1} (USDA report, 2020-21). In India, Uttar Pradesh is having 2nd position in terms of area (0.69 mha), and holds 4th position in term of production (0.89 mt) and producing an average (1290 kg ha^{-1}) (Ministry of Agriculture and Farmers Welfare 2019-20).

India has ever increasing population. According to an estimate, it is going to reach 1.42 and 1.48 billion by 2025 and 2030 respectively. Further, the living standard is also improving resulting in enhanced per capita edible oil consumption. The annual growth of demand for edible oil would be 3.54% during 2011-2030. Accordingly, it is estimated that the per capita edible oil consumption would be 23.1 kg annum^{-1} by the year 2030 from the present level of 16.38 kg annum^{-1}. Therefore, to attain the self-sufficiency in edible oil 34.10 mt of edible oil equivalent to about 102.3 mt of oilseeds would be required (DRMR., 2011).

Rape-seed and mustard 8% share in edible oil production holds promise for self-sufficiency of India in term oilseeds. Crop productivity in India is very poor being 1040 kg ha^{-1} as against world's average of 2000 kg ha^{-1}, 3810 kg ha^{-1} in Chile and 3150 kg ha^{-1} in European Union (USDA report, 2020-21). Cultivation of oilseed crops particularly rape-seed and mustard in marginal land with resource constraints has been a major bottleneck in realizing its yields potential in India. Resource poor farmers are not able to adopt scientific technologies regarding crop management particularly the nutrients. Under marginal resource situation, cultivation of mustard becomes not as much of remunerative to the farmers. This results in a big gap between requirement and production of mustard in India.

The rapeseed-mustard crop growing areas are also witnessing situations that lead to decline in fertility and in turn poor productivity. The nutrient requirement of the Indian mustard in general is high and inadequate supply of nutrient often leads to low nutrient use efficiency**.** Continuous and sole application of inorganic fertilizer induces the soil sickness and disturbs the soil environment to result in low productivity and unsustainability. The application of urea, DAP and MOP have been found to have lower fertilizer efficiency which ranges from 20 - 50 % for nitrogen, 10-25 % for phosphorus, 70-80 % for potassium and 2% for micronutrient owing to various losses which not only contribute to the greenhouse gases emission, certain health hazards such as blue baby syndrome and increase in cost of cultivation. In the context nanotechnology (Nano/Bio nano fertilizers), bio-stimulants and biofertilizers hold promise and can go a long way in sustaining soil health and crop production.

Nanoparticles (dimensions on the order of magnitude 10^{-9}) are a small with at least one dimension less than 100 nm. It should be in such a way that they possess all desired properties such as higher surface area, stability, effectiveness, enhanced targeted activity with less ecotoxicity. NPK Consortia contains selective strains of nitrogen fixing bacteria, PSB, and potash mobilizing bacteria which helps to improve availability of NPK to crops. It mobilizes & converts insoluble plant nutrients to soluble & makes it available to plants. Seaweed extracts supplies nitrogen, phosphorus, potash as well as trace minerals like Zn, Mn, Mg, Fe etc. Bio-stimulants (Sea weed) extract contains natural plant growth substances like Auxins, Gibberellins and Cytokinins. The micro nutrients present in Seaweed extract are in naturally chelated form and are readily available to the plants. Seaweed has been found effective for enhancing yield, pest and frost resistance in vegetable, fruits, flowers, cereals, oilseed and pulses. Sulphur is an important nutrient for the obtaining of higher yield and quality oilseed crops. It is essential for the synthesis of proteins, vitamins and chlorophyll. Foliar spray of water-soluble fertilizers also helps to obtain higher production and productivity of the crop.

The use of balance fertilization by the application of nano nutrients, biofertilizers (*Azotobacter, Azospirillium,* PSB, KMB*)* and Bio-stimulants seems to be of great significance, so as to attain economic yield without any deleterious effect on ecological balance. Information in this respect is meager, hence to meet the national targets and increase seed yield, through adoption of technology inputs, as well as to meet the international targets of quality oilseed.

MATERIAL AND METHODS

Experimental Site. The experiment was conducted at crop research centre of the university located in Indo-Gangetic plains of western Uttar Pradesh. At 29°5′ 34″N latitude, 77°41′ 58″ E longitudes and at an elevation of 230 meters above the mean sea level. Meerut lies 65 km away from Delhi on the national highway 58 linking New Delhi and Dehradun.

Climate and weather condition. Meerut enjoys semi-arid and sub-tropical climate with extremely hot summer and cold winter, minimum and maximum temperature both exhibit a gradual decrease starting from first week of October and reach their minimum in December and January. An increase in the temperature is recorded with effect from 1st week of February and peak value is noticed in 2nd week of May. Occasional frost is also experienced during 2nd fortnight of December and January. The mean weekly minimum temperature records as low as 4.3°C in 2nd week of January. Whereas, mean weekly maximum temperature reaches as high as 36.9°C in 4th week of April. The area receives mean annual rainfall of 800 mm of which more than 80 % during the months of July- September through south-west monsoon. A few winter showers are also received. April and May are the driest months with mean relative humidity of 50 to 55 %, whereas high humidity (92%) is recorded in the month of August. Daily observation on temperature, humidity, sunshine hours and rainfall recorded at meteorological observatory of Gramin Krishi Mausam Sewa Project, SVPUA&T, Meerut - India were collected to work out weekly means as presented in Appendix I and Fig. 1. The crop experienced lowest (4.9°C) of mean weekly minimum temperature in 4thweek of December and highest (32.2°C) in 2nd week of March during 2021. 2nd week of January was most humid (94.86%), however the driest (32.86%) crop season was the 2nd week of March. The crop received rainfall (39.8 mm) during its period.

Soil of the experiment field. A composite soil sample from a depth of 15 cm was taken from the experimental field before initiating the experiment for analysing various soil properties. The soil was sandy clay loam, low in organic carbon and available nitrogen, medium in available phosphorus, available potassium, available sulphur, available zinc and moderately alkaline in reaction.

Variety description. Pusa Vijay (NPJ-93) is a high yielding variety possesses tolerance to different abiotic stresses *viz.* high temperature at seedling stage and salinity up to 12 dS m^{-1}. It is suitable for timely sown irrigated conditions. Average seed yield of this variety is 25.0 q ha^{-1} along with 38.51 % oil content. It takes about 145 days reach to maturity. It is a bold seeded variety. It was released in 2008 at IARI, New Delhi.

Treatments. The fertilizer application was done as per treatments. The recommended dose of NPK & S was taken as 120:40:40:20kg ha^{-1} of N, P_2O_5, K_2O, and S respectively where ever required. Nitrogen, phosphorus, potassium and sulphur were given through urea (46% N), DAP (18 % N & 46% P_2O_5), MOP (60% K_2O) and bentonite sulphur (90% S) respectively. Total amount of P, K, S, Zn and 50% of nitrogen were applied at the time of sowing and remaining half of nitrogen was top dressed in two equal splits after first and second irrigation. Nano Nitrogen (4 ml litre^{-1}), Bio nano zinc (10 ml litre^{-1}), NPK 18:18:18 (5 g litre^{-1}), bio-stimulants (625 ml ha^{-1}) were applied by mixing in 500 litre of water ha^{-1}. The sprays were given 40 days after sowing as per treatments. Where ever, more than one nutrient was required they all were mixed in some 500 litre of water and sprayed in a single run. Hand pressure sprayer fitted with flat fan nozzle.

RESULT AND DISCUSSION

Seed yield (q ha^{-1}). The data pertaining to seed yield are presented in (Table & Fig. 1). Higher seed yield (24.9 q ha^{-1}) was recorded with 100% NPK & S + Nano Zn spray which was at par with 100% NPK & S + Zn (24.0 q ha^{-1}), 100% NPK & S + Bio-stimulants spray (22.7 q ha^{-1}) and 75% NPK & S + Zn + Bio-stimulants spray + Nano N + Nano Zn spray (22.4 q ha^{-1}). On an average there was increased in seed yield 33.87% & 91.53% as compared to 100% NPK & S (18.6 q ha^{-1}) and control (13.0 q ha^{-1}) respectively. A significant increase in grain yield with integrated use of nano, biostimulants and inorganic fertilizers was also reported by Mehta (2017); Khan *et al.* (2009). In preceding section, it was well emphasized that nano nutrient (N and Zn), bio-stimulants with inorganic fertilizers markedly improved overall growth and yield attributes and finally that increased yield of the crop. Proper nourishment of the plants as evinced by the nutrient content and uptake by the crop and consequent low mortality also supported the finding. Besides, nano-N & Zn led promote turn of absorb the water and soil nutrients, then the photosynthesis has been suggested by Wu (2013). A number of studies proved the significance of nano-fertilizers. For instance, Rathore *et al.* (2019), obtained higher grain yield in rice with the application of nano-K fertilizer. This agreement with the findings of Liu *et al.* (2009); Sheikhbaglou *et al.* (2010); Sirisena *et al.* (2013); Jafarzadeh *et al.* (2013); Kumar *et al.* (2014); Hafeez *et al.* (2015); Aziz *et al.* (2016).

Table 1: Seed yield, Stover yield, biological yield and harvest index as influenced by various treatment in mustard crop.

Sr. No.	Treatments	Yield (q ha^{-1})			
		Grain Yield	Stover yield	Biological yield	Harvest index (%)
T_1	Control	13.0	55.6	68.6	18.9
T_2	NPK & S (120:40:40:20)	18.6	69.2	87.9	21.1
T_3	100% NPK & S + Zn	24.0	104.8	128.8	18.6
T_4	100% NPK & S + Bio-stimulants spray	22.7	104.2	127.0	17.9
T_5	100% NPK & S + Nano Zn spray	24.9	113.8	138.6	17.9
T_6	75% NPK & S + NPK Consortia	17.3	65.9	83.2	20.8
T_7	75% NPK & S + Nano N spray	19.0	78.6	97.4	19.5
T_8	75% NPK & S + Nano N spray + Nano Zn spray	19.4	87.0	106.3	18.2
T_9	75% NPK & S + NPK Consortia + Nano Zn spray	21.5	100.4	121.7	17.7
T_{10}	75% NPKS + NPK (18:18:18) 0.5% spray	18.7	72.3	91.0	20.6
T_{11}	75% NPKS + NPK (18:18:18) 0.5% spray + Bio-stimulants spray	19.9	94.4	114.3	17.4
T_{12}	75% NPK & S + Zn + Bio-stimulants spray + Nano N + Nano Zn spray	22.4	102.5	124.9	17.9
SEm±		**1.0**	**4.1**	**5.1**	**1.7**
CD(P = 0.05)		**2.9**	**12.0**	**15.1**	**NS**

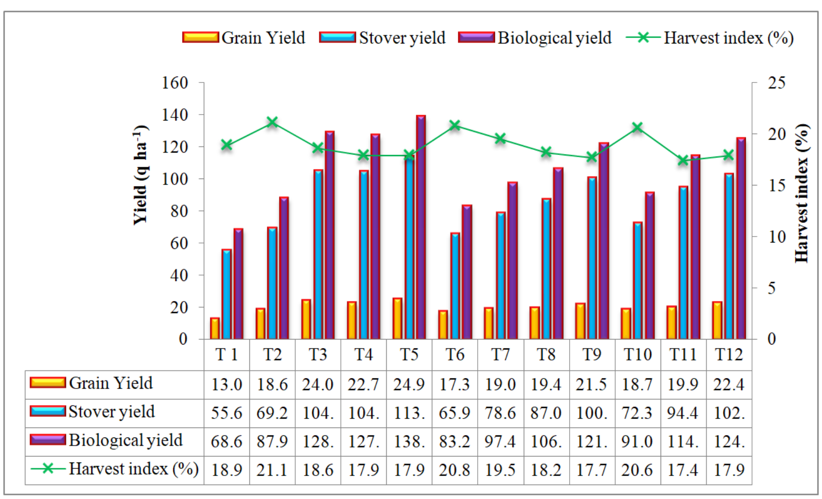

Fig. 1. Effect of doses and sources of nutrients on grain yield, stover yield, biological yield (q ha^{-1}) and harvest index (%) of mustard.

Stover yield (q ha^{-1}). Data pertaining to stover yield as influenced by various treatments is given in (Table & Fig. 1). Stover yield was found significantly higher in the treatment having 100% NPK & S + Nano Zn spray (113.8 q ha^{-1}) and it was found on at par with the treatments 100% NPK & S + Zn (104.8 q ha^{-1}),100% NPK & S + Bio-stimulants spray (104.2 q ha^{-1}) and 75% NPK & S + Zn $^{+}$ Bio-stimulants spray + Nano N + Nano Zn spray (102.5 q ha^{-1}) and lowest stover yield was found in control (55.6 q ha^{-1}).

Biological yield (q ha^{-1}). The data pertaining to biological yield are presented in (Table & Fig. 1). Various treatments have significant effect on biological yield of mustard crop. Maximum biological yield was recorded with 100% NPK & S + Nano Zn spray (138.6 q ha^{-1}) and was statistically at par with 100% NPK & S + Zn (128.8 q ha^{-1}), 100% NPK & S + Bio-stimulants spray (127.0 q ha^{-1}) and 75% NPK & S + Zn $^{+}$ Bio- stimulants spray + Nano N + Nano Zn spray (124.9 q ha^{-1}) treatments. However, lowest biological yield per hectare was recorded under control (75.1 q ha^{-1}).

Harvest index (%). The data on harvest index are presented in (Table & Fig. 1). Higher value of harvest index (21.1) was recorded with the application of NPK & S 120:40:40:20 kg ha^{-1} and varied non significantly with different treatment. However, lowest value of harvest index reported with 75% NPKS + NPK (18:18:18) 0.5% spray + Bio-stimulants spray (17.4%) treatment.

Oil content (%). The data on oil content given in (Table & Fig. 2). The data reveled non-significant effect at nutrient management options on oil content of mustard seed. A critical examination of the data reveled that higher oil content was recorded under 100% NPK & S + Nano Zn spray (39.2 %) treatment and lowest oil content was recorded under control (38.1%).

Table 2: Effect of different doses and sources of nutrient on quality of mustard.

Sr. No.	Treatments	Oil content (%)	Oil yield (kg ha^{-1})
T_1	Control	38.1	495.3
T_2	NPK & S (120:40:40:20)	38.2	710.5
T_3	100% NPK & S + Zn	39.0	936.0
T_4	100% NPK & S + Bio-stimulants spray	38.6	876.2
T_5	100% NPK & S + Nano Zn spray	39.2	976.1
T_6	75% NPK & S + NPK Consortia	38.2	660.9
T_7	75% NPK & S + Nano N spray	38.3	727.7
T_8	75% NPK & S + Nano N spray + Nano Zn spray	38.7	750.8
T_9	75% NPK & S + NPK Consortia + Nano Zn spray	38.7	834.2
T_{10}	75% NPKS + NPK (18:18:18) 0.5% spray	38.5	720.0
T_{11}	75% NPKS + NPK (18:18:18) 0.5% spray + Bio-stimulants spray	38.6	768.1
T_{12}	75% NPK & S + Zn + Bio-stimulants spray + Nano N + Nano Zn spray	38.8	866.9
SEm±		**1.6**	**28.2**
CD(P = 0.05)		**NS**	**83.4**

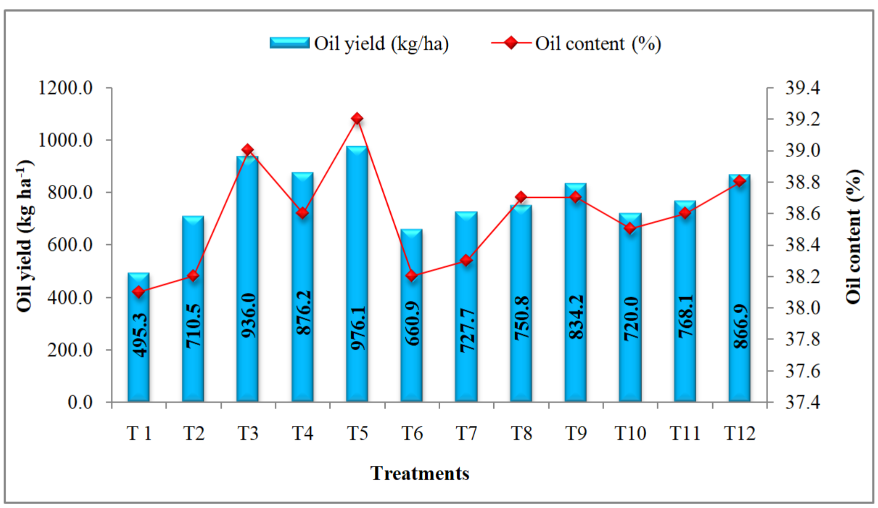

Fig. 2. Effect of doses and sources of nutrients on oil yield (kg ha^{-1}) and oil content (%) of mustard.

Oil yield (kg ha^{-1}). The effect of different nutrients on oil yield was found to be significant (Table & Fig. 2). The oil yield was found higher under the application of 100% NPK & S + Nano Zn spray (976.1 kg ha^{-1}) treatment which was at par with 100% NPK & S + Zn (936.0 kg ha^{-1}) treatments. However, lowest amount of oil yield was obtained under control (495.3 kg ha^{-1}) treatment. In case of control treatment low oil yield because of inadequate amount of nutrient available to the crop and also poor yield of crop. A similar finding was reported by Kumar (2015).

Cost of cultivation. The data given in the Table 3 exhibited variation in cost of cultivation from ₹ 25482 ha^{-1} for the crop grown without nutrient application to ₹ 37488 ha^{-1} for the crop grown with 75% NPK & S + Zn + Bio-stimulants spray + Nano N + Nano Zn spray. The maximum cost of cultivation under 75% NPK & S + Zn + Bio-stimulants spray + Nano N + Nano Zn spray is due to applied of various sources of nutrients. The cost of cultivation was increased by 47.11% in the treatment 75% NPK & S + Zn + Bio-stimulants spray + Nano N + Nano Zn spray as against control. Similar findings reported by have been reported by Rathore *et al.* (2019); Kumar *et al.* (2015).

Gross returns. The data pertaining to gross return are presented in Table (3). Gross returns varied from ₹ 68790 ha^{-1} for the crop rose with no nutrient application to the highest of ₹ 132855 ha^{-1} from the crop raised with 100% NPK & S + Nano Zn spray. The increased in gross return under treatment 100% NPK & S + Nano Zn spray ₹ 64065 as against control and ₹ 35985 as against NPK & S (120:40:40:20).

Net returns. Perusal of data presented in Table (3) revealed that higher net returns were fetched with different nutrient management practices in comparison to control. The crop grown with 100% NPK & S + Nano Zn spray fetched highest net returns of ₹ 95800 ha^{-1}followed by 100% NPK & S + Zn ₹ 94562 ha^{-1}. In case of 75% RDF, crop receiving 75% NPK & S + Zn + Bio-stimulants spray + Nano N + Nano Zn spray gave higher net return by ₹ 38739 ha^{-1} than control and ₹ 16852 ha^{-1} than NPK & S (120:40:40:20).

B: C ratio. The data pertaining to B: C ratios are presented in Table (3). The B: C ratio was highest (3.9) in the crop grown with 100% NPK & S + Zn and lowest (2.7) in Control. The B: C ratio under the treatments was in the descending order of 100% NPK & S + Zn> 100% NPK & S + Bio-stimulants spray > 100% NPK & S + Nano Zn spray> 75% NPKS + NPK (18:18:18) 0.5% spray + Bio-stimulants spray> 75% NPK & S + Nano N spray> 75% NPK & S + NPK Consortia + Nano Zn spray=75% NPKS + NPK (18:18:18) 0.5% spray=75% NPK & S + Zn + Bio-stimulants spray + Nano N + Nano Zn spray> NPK & S (120:40:40:20)> 75% NPK & S + NPK Consortia> Control. Similar findings reported by have been reported by Rathore *et al.* (2019); Kumar *et al.* (2015).

Table 3: Effect of nutrients management on Cost of cultivation, Gross return, Net return and B: C ratio.

Sr. No.	Treatments	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B: C ratio
T_1	Control	25482	68790	43308	2.7
T_2	NPK & S (120:40:40:20)	31675	96870	65195	3.1
T_3	100% NPK & S + Zn	32758	127320	94562	3.9
T_4	100% NPK & S + Bio-stimulants spray	32593	121185	88592	3.7
T_5	100% NPK & S + Nano Zn spray	37055	132855	95800	3.6
T_6	75% NPK & S + NPK Consortia	30280	90330	60050	3.0
T_7	75% NPK & S + Nano N spray	30558	100140	69582	3.3
T_8	75% NPK & S + Nano N spray + Nano Zn spray	36318	103260	66942	2.8
T_9	75% NPK & S + NPK Consortia + Nano Zn spray	35660	115035	79375	3.2
T_{10}	75% NPKS + NPK (18:18:18) 0.5% spray	30758	97800	67042	3.2
T_{11}	75% NPKS + NPK (18:18:18) 0.5% spray + Bio-stimulants spray	31096	106695	75599	3.4
T_{12}	75% NPK & S + Zn + Bio-stimulants spray + Nano N + Nano Zn spray	37488	119535	82047	3.2

CONCLUSION

In view of foregoing facts, it remains no more obscure that nutrient management practices had a significant and profound effect on yield, oil (content & yield) and monetary returns of the crops. Application of nano-nutrient N and Zn, bio-stimulants, NPK consortia, NPK (18:18:18) individually and simultaneously enhanced grain yield and oil (content & yield) significantly. Further, nano/bio nano sources (N & Zn) have potential to promote growth and yield formation in mustard. Mustard crop fertilized with 100% NPK & S (120:40:40:20) + nano Zn (10 ml l^{-1}) spray at 40 DAS resulted significantly higher grain yield as compared to 100% NPK & S and control, but remained at par with 75% NPK & S along with nano- nutrients, bio-stimulants and Zn 5 kg ha^{-1}. However, the net returns (₹ 95800 ha^{-1}) were highest when 100% NPK & S + Nano Zn spray were used, being higher by ₹ 30605 ha^{-1} than 100% NPK & S. Nutrient management practices with nano nutrients, bio-stimulants, NPK consortia, NPK (18:18:18) proved scientifically and economically practices for nutrient management in mustard.

FUTURE SCOPE

In order to arrive at a meaningful recommendation, the further effect of doses and sources of nutrients on growth, yield and quality of mustard need to be reported for one more year. Alternatives for economizing production of nano-nutrients sources particularly N & Zn, bio-stimulants, NPK (18:18:18) and NPK consortia are in entases needed.

Acknowledgement. I feel ecstasy to express my profound regards to advisor Dr. N. S. Rana, Professor, Agronomy, and chairman advisory committee Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, for his ingenious, precious and pragmatic counsel along with his valuable guidance.
Conflict of Interest. None.

REFERENCES

Aziz, H. M. M., Hasaneen, M. N. A. and Omer, A. M. (2016). Nano chitosan-NPK fertilizer enhances the growth and productivity of wheat plants grown in sandy soil. *Spanish Journal of Agricultural Research*, *14*(1): e0902.

DRMR (2011). VISION 2030. Directorate of Rapeseed-Mustard Research, Bharatpur-321303, Rajasthan, p. 30.

Hafeez, A., Razzaq, A., Mahmood, T. and Jhanzab, H. M. (2015). Potential of copper nano-particles to increase growth and yield of wheat. *Journal of Nano science with Advanced Technology*, *1*(1): 6-11.

Jafarzadeh, R., Jami, M. and Hokmabadi, M. (2013). Response of yield and yield components in wheat to soil and foliar application of Nano Potassium fertilizer. *Journal of crop production research (Environmental stresses in Plant Sciences)*, *5*(2): 189-197.

Khan, W., Rayirath, U. P., Subramanian, S., Jithesh, M. N., Rayorath, P., Hodges, D. M. & Prithiviraj, B. (2009). Seaweed extracts as biostimulants of plant growth and development. *Journal of Plant Growth Regulation*, *28*(4), 386-399.

Kumar, R. (2015). Effects of NPKS on growth, yield and quality of late sowntoria varieties (*Brassica rapa* L. var. *toria*) under rainfed condition of north-east India. *Bangladesh Journal of Botany*, *44*(4): 521-528.

Kumar, R., Pandey, D. S., Singh, V. P. and Singh, I. P. (2014). Nano-technology for better fertilizer use (Research Experiences at Pantnagar). *Research Bulletin no.* 201.

Liu J., Zhang Y. and Zhang Z. (2009). The application research on nano-biotechnology to promote increasing vegetable production. *Hubei Agricultural Sciences*, *1*: 20-25.

Mehta, S. (2017). Effect of integrated use of nano and non-nano-fertilizers on quality and productivity of wheat (*Triticum aestivum* L.) (Doctoral dissertation, Sher-E-Kashmir University of Agricultural Sciences and Technology of Jammu).

Ministry of Agriculture and Farmers Welfare report (2019-20).

Rathore, S. S., Shekhawat, K. A., Singh, R. K., Updhyay, P. K., Shekhawat, R., and Premi, O. P. (2019). Effect of nano-particles on growth, productivity, profitability of Indian mustard (*Brassica juncea*) under semi-arid conditions. *Indian Journal of Agricultural Sciences*, *89*(7), 1145-1150.

Sheikhbaglou, R., Sedghi, M., Tajbakhsh, S. M. and Seyed-Sharifi, R. (2010). Effect of nano iron particles on agronomic traits of soybean. *Science Biological*, *2*(2): 112– 113.

Sirisena, D. N, Dissanayake D. M. N., Somaweera K. A. T. N., Karunaratne V. and Kottegoda, N. (2013). Use of Nano-K fertilizer as a source of potassium in rice cultivation. *Annals of Sri Lanka Department of Agriculture*, *15*: 257-262.

USDA Report. (2020-21). pp:11-12.

Wu, M. (2013). Effects of incorporation of nano-carbon into slow-released fertilizer on rice yield and nitrogen loss in surface water of paddy soil. *Advance Journal of Food Science and Technology, 5*: 398-403.

How to cite this article: Sandeep Kumar Verma, N.S. Rana, Vivek, B.P. Dhyani, Bhim Singh, Aparna Verma and Durgesh Kumar Maurya (2022). Effect of Novel Sources of Nutrients, their Dose and Mode of Application on Yield, quality and Profitability of Indian Mustard [*Brassica juncea* (L.) Czern & Coss]. *Biological Forum – An International Journal*, *14*(3): 1385-1390.