Ann. Agric. Res. New Series Vol. 44 (1) : 9-15 (2023)

Effect of different nutrient management options on growth and yield of basmati rice cultivars

Ashutosh Kumar Rai[1], U.P. Shahi[2*], B.P. Dhyani[3], S.P. Singh[4], Kamal Khilari[5], Adesh Singh[6] and Anand Singh[7]

Department of Soil Science & Agril. Chemistry, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.)

Received: December 2022; Revised Accepted: March 2023

Abstract

An experiment entitled ''Effect of different nutrient management options on Growth and yield of basmati rice cultivars'' was conducted at the Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.) during *kharif* season of 2020 to 2021. The experiment was conducted in split plot design with 3 basmati rice varieties in main plots and 5 nutrient options in sub plots. The results revealed that the application of integrated nutrient management (50% inorganic + 50 % organic) lead to higher plant height and dry matter accumulation of all basmati varieties at 60 DAT and at harvest. However, at 30 DAT no significant difference in plant height was observed. The application of nutrients as integrated nutrient management-INM as in T_3-(50% inorganic +50% organic) increased plant height of basmati rice significantly by 33.41,1919 and 8.23% at 60 DAT while 33.34,30.33 and 13.15% at harvest over control (T_1), 5% jeevamruit (T_5) and 100% organic(T_2), respectively and it was *at par* with 100% inorganic. The maximum numberof tillers m^{-2} (308.29) and dry matter accumulation (788.15 g m^{-2}) at harvest whilecrop growth rate-CGR (11.16 $gm^{-2}day^{-1}$) from 60 DAT to harvest stage were registered with application nutrients as INM (50% inorganic + 50% organic). The use of INM enhanced the SPAD (Subsystem Positioning Aid Device) reading by 18.36, 15.52 and 2.04% at 60 DAT and 35.12, 24.15 and 7.09% at 75 DAT over control, 5% jeevamruit and 100% organics, respectively. The grain, straw, and biological yield of basmati rice due to different nutrient management options differ significantly and under integrated nutrient management grain yield increased by 119.51, 102.20 and 18.84% while straw yield by 64.39, 70.70 and 7.64% over control, 5% jeevamruit and 100% organic, respectively while remain *at par* with 100% inorganic. It is concluded that integrated nutrient management using 50% inorganic + 50% organic enhanced the productivity of basmati rice cultivars.

Key words: Basmati Rice, Growth and yield, Nutrient management options, Jeevamruit

Basmati first came to the Middle East by Indian traders and now it has become the pride of India in the world of rice production. India is now producing over the (70 percent) of the world's Basmati rice. Basmati rice cultivation is traditionally practiced on north and north-western regions of the Indian sub-continent with best quality rice's produced on both sides of Indus River (Sarvan *et al.,* 2019). Export of basmati rice from India has grown steadily during the last decade. Basmati rice from India and Pakistan contributes about 10 per cent of the world trade. Production of high-quality aromatic rice by the farmers for domestic as well as export purpose is a major concern of future agricultural strategy. Nutrient manage-

[1]Research Scholar, Soil Science & Agril. Chemistry, SVPUAT, Meerut; [2,4]Assoc. Professor, Soil Science & Agril. Chemistry, SVPUAT, Meerut; [3]Professor, Soil Science & Agril. Chemistry, SVPUAT, Meerut; [5]Professor, Plant Pathology, SVPUAT, Meerut; [6]Assitt. Professor, Agronomy, SVPUAT, Meerut; [7]SRF, Soil Science & Agril. Chemistry, SVPUAT, Meerut; *Corresponding author: upshahi@gmail.com

ment is one of the important factors for quality rice production. Several studies have revealed that the use of combinations of organic andinorganic fertilizers results in a consistent supply of nutrients by which the maximum plant height was obtained. (Ram *et al.* 2020) revealed that yield improvements with INM were due to instantaneous and rapid supply of nutrients through chemical fertilizers and steady supply through mineralization of FYM for prolonged period. The application of organics along with chemical fertilizers perhaps minimizes the loss of N and increases its availability throughout the crop growing period through formation of organic-mineral complexes. Excessive use of fertilizers will cause environmental pollution and will destroy the balance of the ecosystem that is one of the major problems (Zaller, 2007).

Chemical (inorganic) and organic fertilizers (OFs) have been widely used by farmers to supplement soil nutrients. Chemical fertilizers contain mineral nutrients in high concentrations (N, P, and K) that are soluble and readily plant-available. On the other hand, OFs are derived from animal manure and crop residues. OF application in soil offers several benefits such as building up soil organic matter, increases soil water holding capacity, reduces soil compaction, increases soil porosity, and improves soil structure.

Organic manures serve as the carbon and energy source for proliferation of microorganisms, which may alter the activities of different enzymes. Incorporation of organic manures in the soil affects chemical and biological environment but also affects the nutrient availability to crop plants and microorganisms. A promising approach is to develop effective fertilization strategies that can encourage agricultural sustainability by promoting soil microbial biomass and operation by integrating organic modifications with reduced chemical fertilizer (Mandal *et al*., 2007). The balance fertilization through integrated use of manure, inorganic fertilizer and biofertilizer along with micronutrients has been found useful in rice crop (Yadav *et al.,* 2013). Recently nutrient management through natural farming is discussion popular among the farmers and scientist. Jevamruit is one of the components of natural farming, Jeevamruit encourages a great deal of biological activity in the soil and helps the crop access the nutrients. Therefore, it is virtually a paying proposition to employ fermented liquid manures in such a condition. Beneficial organisms continue to exist in these liquid manures and are useful for phosphate solubilization, nitrogen fixation etc. Application of these organic liquid formulations will significantly increase soil microbial population and activity. Crop growth and yield are thereby positively impacted.

Materials and Methods

Field Experiments were conducted during *kharif* seasons of 2020 and 2021at Crop Research Centre (Campus) Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut, situated at latitude of 29^{o}04' North and longitude of 77^{o}42' east and at an altitude of 227 metre above mean sea level. It lies in the heart of Western Uttar Pradesh and has subtropical climate. The rainfall received during crop season 331 mm and 833.50mm in 2020 and 2021, respectively. Soil of experimental field was sandy-loam in texture having pH 8.10, low in available N (195 kg/ha), organic carbon (0.38%), medium in available P (19.6 kg/ha) and K (275 kg/ha). Three basmati rice varieties *viz.* V_1-Pusa Basmati-1121, V_2-Pusa-1509 and V_3-Pusa Basmati-1718 were taken in the main plot. Five treatments of nutrient management *viz.* T_1 (Control), T_2 (100% Inorganic Fertilizer) T_3 (INM-50% inorganic and 50% organic), T_4-(100% Organic fertilizer through 1/3rd of each component, FYM+VC+ PM), T_5-(Low budget Natural Farming-5% jeevamruit) were applied in sub plots and replicated thrice in split plot design. Twenty-five days old seedlings were transplanted at the spacing of 20 × 15 cm spacing with two seedlings hill^{-1}. At final puddling 40 kg phosphorus and 30 kg potash through DAP and MOP, respectively were applied as per treatments in T_2(100% inorganic) and in T_3(50% inorganic + 50% organic sources) were used and in T_4(100% organic) on the basis of nitrogen content of applied organic sources and in T_5 5% jevamruit solution applied. Nitrogen was applied @ 100 kg ha^{-1} as urea into two splits; half at the time of transplanting and remaining half at the time of maximum tillering and at panicle initiation stage equally as per the treatments. Organic sources of fertilizer *viz* FYM, vermicompost, and poultry manure were applied 15 day before the sowing of crop as per treatment and well mixed in the soil. Five hills were randomly selected and tagged for recording plant morphological parameters (plant height (cm), number of tillers m^{-2} and dry matter accumulation gm^{-2}) at 30, 60 and at harvest stage. A chlorophyll meter (SPAD-502 plus, Konica Minolta Optics, INC Japan) was used to take SPAD reading at 30, 60 and 75 DAT on the uppermost fully expanded leaf. For dry matter accumulation the plant sample from one meter row length was taken and dried in hot-air oven at 65°C till it attains constant weight. The crop harvested from each net plot was bundled up separately and allowed for drying in sunand threshed individually plot-wise by using pedal operated paddy thresher. Cleaning of the grainwas done after threshing and then dried in sun to a constant weight to record the final yield and grain, straw, biological yield (grains + straw) was recorded in kg $plot^{-1}$ and then converted into q ha^{-1}. All the parameters were subjected to statistical analysis with analysis of variance for split plot design. The evaluation of critical difference (CD) was done at 5% level of significance.

Results and Discussion

Effect of Different Nutrient Management Options on Plant height

Plant heights of different varieties of basmati rice at different stages were significantly affected due to different nutrient management options (Table 1). The maximum plant height was recorded with V_1-Pusa basmati 1121 *i.e.* 78.16, 113.36 and 126.18 cm followed by V_3- Pusa basmati 1718 *i.e.*77.49, 113.03 and 115.56 cm and V_2-Pusa basmati 1509 *i.e.* 76.44, 101.49 and 108.72 cm at 30, 60 DAT and at harvest stage, respectively. Under nutrients management options, the maximum plant height (134.21cm) was found under T_3-INM at harvest which was at par with T_2-100% inorganic (127.66 cm) and significantly higher over all other treatments. The plant height at harvest under T_4-100% organic (118.61 cm) was found significantly higher as compared to T_5-5% jeevamrit (102.97 cm) and T_1 control (100.65 cm). At harvest stage plant height under T_3 was increased by 33.34, 13.15 and 30.33% over T_1, T_4 and T_5. The increase in plant height in integrated nutrient management practices might be due to the increased nutrient availability which increased the meristematic cellular activity like cell division and elongation expressing in increasing measured variables like plant height and a similar trend was observed in the findings of (Ram *et al.,* 2020; Kumar *et al.,* 2010; Babar and Dongale, 2011)

Effect of Different Nutrient Management Options on Number of Tillers m^{-2}

The number of tillers m^{-2} was significantly influenced by different varieties of basmati rice which is presented as pooled data in Table 2. The maximum no. of tiller m^{-2} was observed in V_1-Pusa basmati 1121 *i.e.*128.63, 318.32 and 286.16 followed by V_3-Pusa basmati 1718 *i.e.*118.95, 294.53 and 267.33 and V_2-Pusa basmati 1509*i.e.*114.01, 284.72 and 256.24 cm at 30, 60 DAT and at harvest, respectively. The effect of different nutrient management practices was significantly increased no. of tiller in T_3-INM, which was at par with T_2-100% inorganic while significantly higher over rest of the treatments. The T_4-100% organic was higher 134.17, 336.77 and 302.74 at 30, 60, DAT and at harvest stage, respectively as compared to T_5-5% jeevamruit and T_1control. At harvest stage the tiller m^{-2} of Pusa-1121 was increased by 11.67 and 7.04% over Pusa-1509 and Pusa-1718 while in nutrient management options it increased under T_3-INM by 51.45, 1.83 and 33.92% over T_1, T_4 and T_5. A combined application of inorganic and organic source of nutrients as in INM supply the essential nutrients for plant growth and development as well as in 100% organic plots FYM and vermicompost in combination with poultry manure supplied the nutrients during whole growth period (Kumar *et al.,* 2012). These results are in conformity with the findings of Mirza *et al.* (2010).

Effect of Different Nutrient Management Options on Dry matter accumulation (g m^{-2})

The results pertaining to dry matter accumulation at different stages are present as pooled data in Table 2. The dry matter accumulation was

Table 1. Effect of nutrient options on growth attributes of basmati rice cultivars.

Treatments	Plant height (cm)			Number of tillers (m^{-2})			Dry matter accumulation (gm^{-2})		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
Varieties									
Pusa-1121 (V_1)	78.16	113.36	126.18	128.63	318.32	286.16	82.04	271.52	705.24
Pusa-1509 (V_2)	76.44	101.49	108.72	114.01	284.72	256.24	67.27	221.26	574.72
Pusa-1718 (V_3)	77.49	113.03	115.56	118.95	294.53	267.33	77.18	254.66	661.46
SEm±	0.68	1.00	0.98	1.92	4.72	4.07	0.71	2.35	6.12
CD (0.05)	NS	4.03	3.97	7.76	19.03	16.43	2.87	9.50	24.68
Nutrient Options									
Control (T_1)	74.35	91.23	100.65	91.66	222.88	203.55	52.13	172.73	448.64
Inorganic 100% (T_2)	79.14	119.09	127.66	135.60	337.81	304.76	91.86	303.43	788.15
INM (50% OS + 50 % IS) (T_3)	80.65	121.71	134.21	137.17	342.95	308.29	95.67	314.82	817.71
Organic 100% (T_4)	77.10	112.45	118.61	134.17	336.77	302.74	85.37	281.14	730.23
Jeevamrit (5%) (T_5)	75.58	101.99	102.97	103.50	255.55	230.20	52.46	173.62	450.96
SEm±	1.73	2.49	2.68	3.29	8.67	9.35	1.81	6.00	15.59
CD (0.05)	NS	7.32	7.87	9.68	25.47	27.46	5.34	17.62	45.78

ranged from 67.27 to 82.04, 221.26 to 271.52 and 574.72 to 705.24 g m^{-2} at 30, 60 DAT and at harvest, respectively under different basmati rice cultivars. Among the different varieties of basmati rice maximum dry matter was recorded with T_3-INM *i.e.* 95.67, 314.82 and 817.71g m^{-2} which was at par with T_2-100% inorganic *i.e.* 91.86, 303.43 and 788.15g m^{-2}. The dry matter accumulation under T_4-100% organic was 85.37, 281.14 and 730.23 gm^{-2} at 30, 60 DAT and at harvest, respectively which was significantly higher over T_1 and T_5. The dry matter accumulation at harvest stage under T_3 was increased by 82.26, 11.97 and 81.32% over T_1, T_4 and T_5, respectively while under T_4 it was increased by 62.76 and 61.92% over T_1 and T_5, respectively. This might be due to the FYM provide the better growing condition to plants by continuous supply of nutrients and improvement of soil properties through the application of vermicompost significantly stimulates the growth of rice. Combined application of organic along with the inorganic fertilizers significantly recorded high dry matter accumulation over control Murali and Setty (2004). Investigators EL–Agodi *et al.*, (2011) reported that the application of FYM increased plant growth and the dry mat-

Table 2. Effect of nutrient options on growth and yield of basmati rice cultivars.

Treatments	Crop Growth Rate ($g\ m^{-2} day^{-1}$)		SPAD Reading			Rice Yield(qha^{-1})		
	30-60 DAT	DAT -At 60 harvest	30 DAT	60 DAT	At harvest	Grain Yield	Straw Yield	Biological Yield
Varieties								
Pusa-1121 (V_1)	9.48	8.32	46.12	49.35	44.93	32.03	47.82	79.85
Pusa-1509 (V_2)	7.70	10.77	42.62	47.39	37.94	24.88	41.94	66.83
Pusa-1718 (V_3)	8.88	7.79	44.70	49.21	44.98	30.15	46.77	76.91
SEm±	0.08	0.07	1.14	0.96	0.44	0.45	0.76	1.18
CD (0.05)	0.33	0.31	NS	NS	1.78	1.84	3.00	4.77
Nutrient Options								
Control (T_1)	6.03	6.33	39.25	43.95	35.53	17.76	33.69	51.45
Inorganic 100% (T_2)	10.58	10.95	47.43	51.26	46.04	36.29	54.64	90.93
INM (50% OS + 50 % IS) (T_3)	10.96	11.16	48.45	52.02	48.01	38.99	55.38	94.36
Organic 100% (T_4)	9.80	10.09	46.11	50.98	44.83	32.79	51.40	84.19
Jeevamrit (5%) (T_5)	6.06	6.27	41.15	45.03	38.67	19.28	32.44	52.22
SEm±	0.20	0.21	1.06	1.51	0.96	1.81	1.33	2.09
CD (0.05)	0.61	0.64	3.12	4.45	2.83	2.37	3.89	6.15

ter production. Similarly, vermicompost also had a positive effect on vegetative growth, stimulating suit and root development (Edward *et al.* 2004). EL–Agodi *et al.,* (2011) observed that the increase in organic carbon content in treatments with combination of both organic and inorganic sources may be attributed to higher biomass addition to soil through crop residues.

Effect of Different Nutrient Management Options on Crop growth rate (CGR)

Crop growth rate is an indication that which nutrient option is more effective in increasing the yield of basmati rice. Among different cultivars of basmati rice, an increasing crop growth rate from 30-60 DAT (7.70 g m^{-2} day^{-1}) to 60 DAT – harvest (10.77 g m^{-2} day^{-1}) was recorded under V_2 (Pusa-1509) (Table 2). However, decreasing trends in CGR was observed under V_1 (Pusa basmati-1121) and V_3 (Pusa basmati 1718) from 30-60 DAT (9.48 and 8.88 g m^{-2} day^{-1}) to 60 DAT – harvest (8.32 and 7.79 g m^{-2} day^{-1}), respectively. In different nutrient management options, the crop growth rate was slower during 30-60 DAT and substantially increased during 60 DAT- At harvest and it may be due to the increasing uptake of nutrient as the crop duration increased. Among different nutrient management options, maximum CGR during 30-60 DAT (10.96 g m^{-2} day^{-1}) and 60 DAT – harvest (11.16g m^{-2} day^{-1}) was recorded under T_3-INM followed by T_2- 100% inorganic and T_4-100% organic. CGR during 60 DAT-harvest was 76.3, 10.6 and 78.0 % higher under T_3- INM in comparison to T_1-control, T_4-100% organic and T_5- 5 % jeevamruit, respectively. Similarly, CGR was 59.4 and 60.9% higher during 60 DAT-harvest under T_4-100% organic as compared to T_1-control and T_5-5 % jeevamruit, respectively. High CGR might be due to accumulation of food material through photosynthesis during growth period of the crop and then it distributed towards the root and shoot. The crop growth increased in early planting possibly due to favourable environmental conditions, such as temperature and relative humidity during its different phenophases compared to late planting (Verma *et al.*, 2008 and Jena *et al.*, 2010) implies easy uptake of macro and micro nutrients from soil, might have increased the photosynthetic.

Effect of Different Nutrient Management Options on SPAD value

The SPAD value reflected performance of different varieties and nutrient options presented in Table 2. The effect of various nutrient management options at both 30 and 60 DAT the SPAD value was not significant in different varieties of basmati rice cultivars but at 75 DAT it ranged from 37.94 to 44.93 and significantly difference was observed between all three cultivars. Irrespective of cultivar and nutrient management options, SPAD value in basmati rice increased up to 60 DAT and then decreased during later stages. SPAD value at 75 DAT was 35.1%, 7.1% and 24.2% higher under T_3-INM as compared to T_1-control, T_4-100% organic and T_5-5 % jeevamruit, respectively. Similarly, SPAD value at 75 DAT under T_4 100 % organic was 26.17% and 15.92 % higher compared to T_1-control and T_5-5% jeevamruit, respectively. The above increment in SPAD value under T_3-INM clearly reflected the importance of better nutrient management than any other nutrient management options. Singh *et al.* (2017)

Effect of Different Nutrient Management Options on grain and straw yield

The pooled data regarding yield of rice grain and straw is presented Table 2 showed a significant different between both the factors rice varieties and different nutrient management options. The grain yield under different basmati rice varieties ranged from 24.88 to 32.03 q ha^{-1} while straw yield ranged from 41.94 to 47.82 q ha^{-1}. The grain yield of V_1-Pusa basmati 1121 was increased by 28.74% and 6.25% while straw yield 14.01% and 2.25 % over V_2-Pusa basmati 1509 and V_3-Pusa basmati 1718. Under the nutrient management system the maximum grain yield was found under T_3-INM i.e. 38.99 q ha^{-1} while minimum 17.76 q ha^{-1} under T_1-control. The grain yield of basmati riceunder T_3 INM was increased by 119.51%, 18.84% and 102.23% while straw yield 64.41%, 7.64%, and 70.70% over T_1-control, T_4-100% organic and T_5-5 % jeevamruit, respectively. Similar reports on higher yield due to application of inorganic and organic N sources applied either singly or in combination were reported earlier by Islam *et al.* (2014) and Sohel *et al*. (2016). The integration of organic and inorganic sources might have synergistic effect to produce maximum grain yield of basmati rice. Increase in straw yield with integrated nutrient treatments could partly be attributed to its direct influence on dry matter production of vegetative part and indirectly through increased morphological parameters of growth. The results are also in conformity with the findings of Pandey *et al*. (2007) and Singh *et al*., 2021.

Conclusion

The overall findings of this study conclude that the cultivation of basmati rice with the combined use of 50% inorganic + 50% organic resulted in significant improvement in growth, development and yield. The low budget natural farming by using jeevamruit can be an option over absolute control by a yield reduction of 50.55 and 41.20% over INM (T_3) and T_4 (100% organic), respectively.

References

Babar, S. and Dongale, J.H. 2011. Effect of integrated use of inorganic and organic manure on yield and monetary returns of mustard-cowpea-rice cropping sequence in lateritic soils of Konkan. *Journal of Soils and Crops.* **21**: 225-233.

Edwards, C.A., Domínguez, J. and Arancon, N.Q. 2004. The influence of vermicomposts on plant growth and pest incidence. In: Shakir SH and Mikhaïl WZA(Eds). *Soil Zoology for Sustainable Development in the 21st century* 397-420, Cairo.

Agodi El, M.W.M., Zehery El, T.M. and Hasnaa, L.L. 2011. Effect of chicken manure and gypsum of sugar beet (*Betavulgaris* var. *saccharifora*) under saline conduction. *Journal of Soil Sciences and Agricultural Engineering. Mansoura University.* **2**: 701- 716.

Hossaen, M.A., Shamsuddoha, A.T.M., Paul, A., Bhuiyan, M.S.I. and Zaheer. 2011. Efficacy of different organic manures and inorganic fertilizer on the yield and yield attributes of Bororice. *The Agriculturists.* **9**(2): 117-125.

Islam, M.S., Paul, A.K., Bari, F., Shahriar, S., Sultana, M.S. and Hosain, M.T. 2014. Integrated effect of organic manures andnitrogen on yield contributing characters and yield of rice (BRRI dhan29). *International Journal of Science and Research.* **4**(11):1-6.

Jena, S., Poonam, A. and Nayak, B.C. 2010. Response of hybrid rice to time of planting and plant density. *Oryza*. **47**(1): 48–52.

Kumar, J., Yadav, M.P. and Kedar, P. 2010. Production potential of hybrid rice (*Oryza sativa* L.) as influenced byintegrated nutrient management. *Crop Research.* **39**: 20-23.

Kumar, M., Yaduvanshi, N.P.S. and Singh, Y.V. 2012. Effects of Integrated Nutrient Management on Rice Yield, Nutrient Uptake and Soil Fertility Status in Reclaimed Sodic Soils. *Journal of the Indian Society of Soil Science.* **60**(2): 32-137.

Mandal, A., Patra, A.K., Sing, D., Swarup, A. and Ebhin, M.R. 2007. Effect of long-term application of manure and fertilizer on biological and biochemical activities in soil during crop development stages. *Bioresource Technology.* **98** : 3585-3592.

Mirza, H., Ahamed, K.U., Rahmatullah, N.M., Akhter, N., Nahar, K. and Rahman, M.L. 2010. Plant growth characters and productivity of wet land rice (*Oryza sativa*) as affected by application of different manures. *Emirates Journal of Food and Agriculture.* **22**: 46-58.

Murali, M.K. and Setty, R.A. 2004. Effect of fertilizer, vermicompost and triacontanol on growth and yield of scented rice. *Oryza,* **4**: 57-59.

Niang, H.F., Liu, Z.H., Wang, Q.S., Lin, Z.M., Chen, S.J., Li, G.H., Wang, S.H. and Ding, Y.F. 2009. Effect of nitrogen fertilizer application on grain phytic acid and protein concentrations in japonica rice and its variations with genotypes. *Journal of Cereal Science.* **50**(1): 49-55.

Pandey, N., Verma, A.K. and Tripathi, A.R. 2007. Integrated nutrient management in transplanted hybridrice (*Oryza sativa*). *Indian Journal of Agronomy,* **52**: 40-42.

Parihar, C.M., Rana, K.S. and Kantwa, S.R. 2010. Nutrient management in pearlmillet (*Pennisetum glaucum*)-mustard (*Brassica juncea*) cropping system as affected by land configuration underlimited irrigation. *Indian Journal of Agronomy.* **55**: 191-196.

Ram, M.S., Shankar, T., Maitra, S., Adhikary, R. and Swamy, G.V.V.S. 2020. Productivity nutrient uptake and nutrient use efficiency of summer rice (*Oryza sativa*) as influenced by integrated nutrient management practices. *Crop Research.* **55**(3-4): 65-72.

Sharma, S.K. and Sharma, S.N. 2002. Integrated nutrient management for sustainability of rice-wheat cropping system. *Indian Journal of Agricultural Science.* **72**: 573-576.

Singh S., Bohra J.S., Singh Y.V., Upadhyay A. K., Verma S. S., Mishra P. K. and Raghuveer, M. 2017. Effect of Integrated Nutrient Management on Growth and Development Stages of Rice under Rice–Wheat Ecosystem. *International Journal of Current Nicrobiology and Applied Sciences.* (2017) **6**(7): 2032-2042

Singh, A., Shahi, U.P., Dhyani, B.P., Kumar, A., Kumar, S., Vivek and Kumar, A. 2021. Response of bread wheat and nutrient removal with new micronutrient molecules fertilization. *Indian Journal of Agricultural Sciences.* **91**(5): 708–12.

Sohel, M.H., Sarker, A., Razzak, Md. A. and Hashem, Md. A. 2016. Integrated use of organic and inorganic fertilizers on the growth and yield of Boro rice (cv. BRRI dhan 29). *Journal of Bioscience and Agricultural Research.* **10**(01): 857-865.

Sravan, U.S. and Singh, S.P. 2019. Effect of integrated nutrient management on yield and quality of Basmati rice varieties. *Journal of Agricultural Science*. **11**(5):1-6.

Sutaliya, R. and Singh, R.N. 2005. Effect of planting time, fertility level and phosphate-solubilizing bacteria on growth, yield and yield attributes of winter maize (*Zea mays*) under rice (*Oryza sativa*) - maize cropping system. *Indian Journal of Agronomy*. **50**(3): 173-75.

Verma, A.K., Pandey, N. and Tripathi, R.S. 2008. Effect of planting time and nitrogen level on physiological parameters and grain yield of hybrid rice. *Oryza.* **45**(4) : 300–302.

Yadav, B., Khamparia, R.S. and Kumar, R. 2013. Effect of zinc and organic application on various zinc fractions under direct-seeded rice in Vertisol. *Journal of the Indian Society of Soil Science.* **61**: 128-134.

Zaller, J.G. 2007. Vermicompost as a substitute for peat in potting media Effects on germination, biomass allocation, yields and fruit quality of three tomato varieties. *Scientia Horticulturae.* **112**: 191-199.