Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(1): 1856-1859
Received: 02-11-2020
Accepted: 12-12-2020

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Intregrated nutrient management for sustainable wheat (*Triticum aestivum* L.) production in Western Uttar Pradesh

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Abstract
The field experiment was conducted at CRC Farm Chirrori, SardarVallabhbhai Patel Agriculture University Meerut during *rabi* 2011-12 and 2012-13. To study the integrated nutrient management for sustainable wheat production in western U.P. Addition of 100% NPK (RDF-recommended dose of fertilizer *i.e* 120, 60, 40 kg NPK ha^{-1} was recorded significantly higher value of yield and yield attributes in terms of spikelet's spike^{-1}, spike length (cm), 1000-grain weight (g), harvest index (%), biological yield and grain yield (q ha^{-1}) in grain (41.50 and 43.78 q ha^{-1}) and straw (60.90 and 62.26 q ha^{-1}) yield followed by 75% NPK + 1 t/ha vermicompost+ *Azosprillium* which is in grain (41.08 and 42.36 q ha^{-1}) and straw (60.42 and 60.90 q ha^{-1}) yield. Available nitrogen content is also increased compared with its soil status under this treatment (75% NPK+1 t/ha vermicompost+ *Azosprillium*). The content of organic carbon and available NPK in soil after harvest is increase with the combined application of organic and inorganic with biofertilizer. Integrating of 75% NPK + 1 t/ha vermicompost+ *Azosprillium* found more productivity, and monetary return by maintain or improving the residual soil fertility status after the harvest of wheat crop.

Keywords: Nutrient management, FYM, pressmud, vermicompost, *Azsoprillium*, yield attributes, available NPK and organic carbon

Introduction
Wheat (*Triticum aestivum* L.) is the second most important cereal crop of the world after rice, both in terms of area and production. In India wheat is the second most important food crop next to rice and it contributes nearly 35% to the national food basket. Among winter crops, it contributes about 49% of the food grains in 2012–13. It provides more than 19 % calories and 21 % of the protein to the world population (FAO, 2011) besides it is major source of energy, protein and dietary fibre in human nutrition since decades. In India, it covers an area of 29.65 million hectare with total production of 93.50 million tons and average productivity of 31.53 q ha^{-1} (FAO, 2013) [13]. Minimum, optimum and maximum (cardinal) temperature for germination of wheat crop are 4 ^{0} to 5 ^{0}C, 24 ^{0}C to 25 ^{0}C and 30 ^{0}C to 32 ^{0}C for growth and development. In western Uttar Pradesh it is grown under rice-wheat and sugarcane cropping. Enhancement of wheat production from limited land area is great challenge for Indian agriculturist. Apart from developing high yielding wheat varieties, integrated nutrient management will be required to boost wheat production.
Plant nutrient plays an important role in growth and productivity of a crop. As wheat crop is highly responsive to applied nutrient through various sources, a proper fertility management is an important parameter for optimizing the productivity of wheat crop. Wheat is generally grown in intensive cropping system with higher use of inorganic especially nitrogenous fertilizers. This condition is adversely affected and therefore it is needed to supply the nutrient to the crop in combination with organic sources. Indian soil are generally deficient in nutrient particularly nitrogen. Nitrogen fertilization always results in an increase in above ground dry matter and root biomass production which results into higher productivity as well as higher residue left in soil after the harvest of the crop which helps in improving the fertility of soil. The nitrogen use efficiency value become high with combination of FYM and Azosprillum.
Keeping this in view, an attempt was made to evaluate integrated nutrient management on wheat (*Triticum aestivum* L.) Production in Western plain.

Materials and methods
The field experiment was conducted during the *rabi* season of 2011-12 and 2-12-13 at CRC, Chirori of Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, (29^0 13' N, 77^0 68' 43 E, 237 m above mean sea level) Meerut, India.

Climate is semi arid sub tropical with extremes of hot weather in summer and cold in winter season. There is gradual decrease in mean daily temperature from October reaching as low as 2-4 ^{0}C in January and further a gradual increase is registered from February reaching as high as 43-45 ^{0}C in May. The rains are predominantly caused by south-west monsoon which sets in the last week of June, reaches its peak in July-August and withdraws by the end of September. The area receives 862 mm of rains annually on an average, of which 90% is confined to rainy season (July-September). Soil of experimental field was sandy loam with pH of 7.6, Electric Conductivity (EC) 0.24 dSm^{-1}, low in organic C (0.43%), available N (245.6 kg ha^{-1}), medium in available P (13.4 kg ha^{-1}) and K (185 kg ha^{-1}). A range of mean weekly maximum temperature varied from 14.1 ^{0}C to 34.8 ^{0}C, and the mean weekly minimum temperature ranged from 2.9 ^{0}C to 19.71^{0}C during 2011-12. During next season i.e. 2012-13, mean weekly maximum temperature varied from 11.0 ^{0}C to 385.8 ^{0}C, and the mean weekly minimum temperature ranged from 1.2 ^{0}C to 19.7 ^{0}C were recorded in the cropping season. The total of 80 mm rainfall was received during 2011-12 and 184.5 mm during 2012-13. The experiment was laid out in 3 replicates in a RBD (Randomized Block design). Studies were conducted with eleven treatments viz., 100% NPK, 75 % NPK + 3 ton ha^{-1} FYM + *Azosprillium*, 50% NPK + 6 ton ha^{-1} FYM + *Azosprillium*, 25% NPK + 9 ton ha^{-1} FYM + *Azosprillium*, 75 % NPK + 1 ton ha^{-1} pressmud + *Azosprillium*, 50 % NPK + 2 ton ha^{-1} pressmud + *Azosprillium*, 25 % NPK + 3 ton ha^{-1} pressmud + *Azosprillium*,75 % NPK + 1 ton ha^{-1} vermicompost + *Azosprillium*, 50 % NPK + 2 ton ha^{-1} vermicompost + *Azosprillium*, 25 % NPK + 3ton ha^{-1} vermicompost + *Azosprillium*, Control. The experiment is carried out in the same field during both the year. Wheat crop was sown with the row spacing of 20 cm as per treatments. Five irrigations (75 mm irrigation in each) were applied at four critical phenological stages. In regards to fertilizer application of the crop, 120 kg N, 60 kg P_2O_5 and 40 kg K_2O were applied. Out of which, 1/3rd N and full dose of P_2O_5 and K_2O were applied as basal dose at the time of sowing by broadcasting method. The remaining 2/3rd dose of N were applied in two splits at CRI and late tillering stages. Organic manure were applied FYM, Pressmud, Vermicompost and bio fertilizer *Azosprillium* were used to inoculate in soil. Variety of wheat is DBW 16. Total tillers and ears recorded as per metre. Five spike were randomly selected and threshed manually, grains counted and data presented as grains per spike. The sample of 1000-grains collected from each plot, weighed and presented as gram. Total bundle weight was recorded from each plot at the time of harvesting. The crop was threshed and grain were weighed and presented as quintal per hectare. Meteorological data, *viz.*, rainfall, relative humidity, maximum and minimum temperature, were recorded from Agrometeorological observatory, PDFSR, Meerut. Data on yield attributes, biological yield, and harvest index were recorded at crop maturity. Standard procedures were used for chemical analysis of soil and plant sample. The data were analyzed by using the 'Analysis of Variance Technique' as per the procedures described by Panse and Sukhatme, (1967) [8]. The treatment means were compared at 5% level of significance.

Result and Discussion

Yield and yield attributes

The yield of a crop depends upon the source sink relationship and is the cumulative function of various growth parameters and yield attributing components viz; spike length, spikelets per spike, number of grains per spike. Any factors affecting these parameter ultimately affects the biological and economical yields of crop. Applications of vermicompost with inorganic sources of fertilizer at any level were found to improve the yield attributing character (Table 1) grain, straw and biological yield (Table 2) in comparison to control. An increase of 65.51 and 57.14, 62.63 and 62.50; 34.46 per cent of length of spike, spikelets per spike and number of grains per spike was observed during 2011-12 and 2012-13 respectively, with 100% NPK over control. The effect of 100% NPK being statistically at par with 75 % NPK + 1 t ha^{-1} vermicompost+ *Azosprillium* and were superior to control during both years in respect of yield attributing characters. More yield attributes were found in the treatment where organic and inorganic sources of plant nutrients were applied over control. This may be due to effect of organic and inorganic sources on the adequate nutrient supply for longer period, which will affect crop growth and photosynthetic activity. Similar results were reported by Muhammad *et al*. (2008) [6], Patil and Blihore, (2001) [9]. Stimulated vegetative growth of wheat on account of adequate and prolonged supply of essential nutrients in treatment receiving vermicompost and biofertilizer in addition to 75% NPK manifested itself in increase number of effective tillers, grain/spike and test weight similar beneficial effect of INM on yield attributes of wheat has been reported by Sharma *et al.* (2009) [12]. Such improved yield attributes can be linked with balanced nutrition particularly nitrogen with play a vital role in cell division and cell elongation as well as increase in sink size which provide a feedback to sources for production of higher amount of photo-synthate. Higher level of nutrients improved the fertility level of soil and creates congenial condition for better growth and development thus improved the yield attributes. These results are in conformity with those reported by Sen *et al.* (2003) [10], Singh and Yadav (2006) [15] and Ashutosh Barthwal *et al*. (2013) [1].

Application of nutrient management treatments significantly increased the grain, straw and biological yield of wheat during the years of experimentation. The grain and straw yield were recorded significantly higher in the treatments 100% NPK which were 41.50 and 43.78; 60.90 and 62.26 and q ha^{-1} which was at par with 75 % NPK + 1 ton ha^{-1} vermicompost+ *Azosprillium* during both years. Overall the grain yield increased was 72.19 and 73.52, 35.20 and 51.85 per cent over control by the application of 100% NPK, 75 % NPK + 1 t ha^{-1} vermicompost + *Azosprillium* 2011-12 and 2012-13 respectively. The beneficial effect of organic manures on grain, straw yield and yield attributing characters might be assigned to the fact that after proper decomposition and mineralization, these manures supplied available plant nutrients directly to the plants and also had solublising effect on fixed forms of nutrients in soil. Similar findings were also reported by Mubarak and Singh, (2011). The combination use of organic manures and chemical fertilizers enhanced the inherent capacity of soil as reported by Pandey *et al.* (2009) [7], Verma and Mathur, (2009) [16] and Meena *et al.* (2012) [5], Singh and Singh (2005) [14]. The organic manures also increase the adsorptive power of soil for cations and anion particularly phosphates and nitrates and these adsorbed ions are released slowly for the benefit of crop during entire crop growth period leading to higher yields reported by Dhaliwal and Walia, (2008) [2].

Effect on available NPK and organic carbon in soil

Incorporation of organic manures and chemical fertilizers generally affects physical, chemical and biological properties of soil. During this study available N, P and K organic carbon were measuring during 2011-12 and 2012-13 after harvest of crop from various treatments during both years. Available N, P and K increased in soil with the application of different nutrient management treatments during both years. The application of organic manures have been reported not only to improve the nutrient content in the soil but also helps in bringing native nutrients into the available from thus increasing the available nutrient contents in the soil. Moreover, organic manures crates better environment for biological activity in the soil which results into more fixation of N and more solubilising effect on other fixed form of nutrients. The available nitrogen was significantly higher in the treatment 75 % NPK + 1 t ha^{-1} vermicompost+*Azosprillium* followed by 100 % NPK during both the year. The available N of soil also improved from the initial value under these treatments. The highest available phosphorous content was observed with the treatment 75 % NPK + 1 t ha^{-1} vermicompost+*Azosprillium* which was at par with 100 % NPK during both the year. The highest available potassium content was observed with the treatment 75 % NPK + 1 t ha^{-1}.

Table 1: Effect of integrated nutrient management on Grain, straw, biological yield (q ha^{-1}) and harvest index (%) of wheat.

Treatment	Length of spike (cm)		Number of spikelets/spike		Number of grains/spike		Grain Yield (q ha^{-1})		Straw Yield (q ha^{-1})	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
T_1	9.6	9.9	14.8	15.6	35.5	36.7	41.50	43.78	60.90	62.26
T_2	9.1	9.4	14.2	14.8	33.9	35.6	39.70	40.86	60.05	60.54
T_3	8.5	9.1	13.1	13.6	32.1	34.3	37.26	38.63	58.86	59.82
T_4	7.6	8.7	11.9	12.8	29.8	32.2	34.85	36.45	56.63	58.69
T_5	8.7	9.2	13.9	14.1	32.3	34.2	38.59	39.94	59.26	59.94
T_6	8.1	8.8	12.4	13.0	30.1	32.8	36.14	37.48	58.66	59.71
T_7	7.4	8.5	11.3	12.4	28.6	31.7	34.50	35.94	56.38	58.36
T_8	9.3	9.6	14.6	15.3	34.8	36.1	41.08	42.36	60.42	60.90
T_9	9.0	9.3	13.7	14.2	32.4	35.2	39.08	40.45	59.58	60.15
T_{10}	8.4	8.9	12.6	13.6	30.9	33.6	37.00	38.45	58.72	59.78
Control	5.8	6.3	9.1	9.6	26.4	27.8	24.10	25.23	39.46	41.00
SEm(±)	0.15	0.13	0.14	0.23	0.39	0.34	0.55	0.66	0.17	0.40
C.D. (P=0.05)	0.44	0.39	0.43	0.68	1.17	1.01	1.63	1.97	0.50	1.19

Table 2: Effect of integrated nutrient management on Available N, P, K of the soil in wheat.

Treatment	Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})		Organic carbon (%)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
T_1	234.78	235.38	14.24	14.64	179.45	180.35	0.49	0.50
T_2	233.23	233.75	14.02	14.38	178.65	179.25	0.48	0.49
T_3	226.54	227.68	13.45	13.65	176.40	176.70	0.45	0.45
T_4	220.65	220.84	12.56	12.85	173.25	173.43	0.43	0.44
T_5	228.45	230.26	13.60	13.80	177.38	177.76	0.46	0.47
T_6	222.54	222.86	12.89	13.19	174.46	174.66	0.44	0.45
T_7	218.89	219.45	12.14	12.42	173.10	173.28	0.43	0.44
T_8	235.60	236.71	14.64	15.14	180.56	181.06	0.51	0.52
T_9	231.72	232.14	13.79	14.13	177.89	178.19	0.47	0.48
T_{10}	224.05	225.25	13.14	13.32	175.80	176.05	0.45	0.46
Control	200.01	200.73	10.54	10.68	166.75	166.95	0.40	0.42
SEm(±)	0.66	0.80	0.19	0.22	0.54	0.58	0.01	0.01
C.D. (P=0.05)	1.95	2.37	0.58	0.65	1.62	1.73	0.03	0.03

vermicompost+*Azosprillium* which was at par with 100 % NPK during both the year. Lowest available nitrogen, phosphorous and potassium was recorded in control plot during 2011-12 and 2012-13. Increase in nutrients in soil by the application of organic manures was also reported by Sharma *et al.* (2007) [11], Dhaliwal and Walia (2008) [2]. Organic carbon in soil varied significantly among different nutrient treatment. Maximum carbon content was recorded in 75 % NPK + 1 t/ha vermicompost+*Azosprillium* (0.51 and 0.52) was statistically at par with 100% NPK (0.49 and 0.50) during both the years which was significantly higher to control. In soil pH was non significantly different among different nutrient treatments during both the year. Studies conducted by various workers have established the fact of maintenance of soil fertility in terms of improved organic content and available nutrients in soil by application of organic manures in combination with chemical fertilizers in different ratio as Singh *et al.* (2008) [13], Verma and Mathur (2009) [16].

Above result on effect of different nutrient option on available N, P, K indicates that were also reported by Robinson *et al.* (1992). Application of FYM, vermicompost with fertilizer significantly improves the soil health along with enhanced organic carbon in soil that the application of fertilizer alone. Similar result was also reported by Pandey *et al.* (2009) [7]. Inclusion of FYM in the different treatment schedule improved the organic carbon status and available N, P and K in soil. Similar result were also reported by Singh *et al.* (2006) [15] and Hakeem *et al.*, (2010) [14].

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