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Performance of Integrated Nutrient Management on Nutrient Uptake and Productivity of Pearlmillet (*Pennisetum glaucum* L.) - Wheat (*Triticum aestivum* L.) Cropping System

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Abstract **– To find out the performance of integrated nutrient management on nutrient uptake and productivity in pearlmillet (*Pennisetum glaucum* L.) - wheat (*Triticum aestivum* L.) cropping system, an experiment was carried out at CCS Haryana Agricultural University, Hisar during 2009-10. Experiment consisting of 12 treatments *viz.,* T_1 - control (no fertilizer); T_2 - 50% recommended NPK to pearlmillet and wheat; T_3 - 50% recommended NPK to pearlmillet and 100% recommended NPK to wheat; T_4 - 75% recommended NPK to pearlmillet and wheat; T_5 - 100% recommended NPK to pearlmillet and wheat; T_6 - 50% NPK + 50% N (farmyard manure) to pearlmillet and 100% recommended NPK to wheat; T_7 - 75% NPK + 25% N (farmyard manure) to pearlmillet and 75% recommended NPK to wheat; T_8 - 50% NPK + 50% N (wheat straw) to pearlmillet and 100% recommended NPK to wheat; T_9 - 75% NPK + 25% N (wheat straw) to pearlmillet and 75% recommended NPK to wheat; T_{10} - 50% NPK + 50% N (*Sesbania* spp.) to pearlmillet and 100% recommended NPK to wheat; T_{11} - 75% NPK + 25% N (*Sesbania* spp.) to pearlmillet and 75% recommended NPK to wheat and T_{12} - farmers' practice was laid out in randomized block deign with four replication. Results of experiment revealed that maximum uptake of nitrogen, phosphorous and potassium in grain as well as stover/straw was recorded in treatment T_6 in both the crops, which is significantly higher than T_1, T_2, T_3, T_4, T_7, T_8, T_9, T_{10} and T_{12} in pearlmillet and T_1, T_2, T_3, T_4, T_7, T_8, T_9, T_{11} and T_{12} in wheat but statistically at par with T_5 and T_{11} in pearlmillet and T_5 and T_{10} in wheat. Treatment T_6 recorded highest grain and stover/straw yield of pearlmillet and wheat, which is statistically at par with T_5 and T_{10} in wheat and T_5 and T_{11} in pearlmillet but significantly superior to all the other treatments in both the crops. 50% nitrogen in pearlmillet grown in sequence with wheat could be substituted by one or more organic source of nutrients such as farmyard manure, wheat straw or green manure for higher system productivity as well as nutrient uptake by sink.**

Keywords **– Cropping System, FYM, INM, Nutrient Uptake, Pearlmillet-Wheat.**

I. INTRODUCTION

Pearlmillet (*Pennisetum glaucum* L.) - wheat (*Triticum aestivum* L.) is the second most important cropping system after rice-wheat in the Indo-Gangetic Plains of India. It is being realized that when crops are grown in sequence, the fertilizer needs of the cropping sequence as a whole is important than that of the individual crop [11]. This cropping system is followed in an estimated area of 2.26 m ha in India [14]. The contribution of this cropping system in total food grain production is considerably large. Wheat contributes 35% while coarse grains contribute 17.3%. The share of pearlmillet in coarse grains production is 24%. This system is very exhaustive. Further, long term studies being carried out at several locations in India indicated that application of all the needed nutrients through chemical fertilizers have deleterious effect on soil health, leading to unsustainable yields [1]-[17].

Fertilizer (nutrient) is the key component that can be effectively managed to get desired use efficiency under a given situation. Higher food production needs a balance amount of plant nutrients. Without careful management, manures can cause yield loss and lower crop quality as a result of both under and over fertilization. In the last five decades, the food grain production increased by five folds from a low of 50.82 mt in 1950-51 to 252.22 mt in 2015-16 and consumption of fertilizer (N + P + K) has increased from 0.07 to 26.76 mt (in nutrient terms) over the same period. A consumption of 26.76 mt of nutrients comprises 17.37 mt of nitrogen, 6.98 mt of phosphorus and 2.4 mt of Potassium. Consumption of fertilizers (all nutrients) per hectare increased from 1.0 kg to 150.5 kg in 2014-15 [3]. Increased use of chemical fertilizers in an unbalanced manner has created problem of multiple nutrient deficiencies, particularly micronutrients, diminishing soil fertility and unsustainable crop yields. Due to the increased productivity of the crops, the native soils have begun depleting their nutrient reserves and the crops started responding to application of micronutrient fertilizers [7]. This further has led to aggravated micronutrient deficiency in soil system. The soil organic matter plays an important role in improvement of soil physical, chemical and biological properties and ultimately increasing soil productivity and crop yields [15].

Since, the nutrient turnover in soil-plant system is considerably high under intensive cropping system. So, neither the chemical fertilizers nor the organic/ biological sources alone can achieve production sustainability. Even with the so called balance use of NPK fertilizers in long term studies, higher yield levels could not be maintained for years because of emergence of secondary and micro-nutrient deficiency and deterioration in the soil physical environment. Whereas, organic manure alone or in combination with inorganic fertilizers is known to have favourable effect on soil environment, correct the marginal deficiency of secondary and micro-nutrients and enhance the efficiency of applied nutrients. For higher fertilizer use efficiency and sustainability of cropping system, there is need to recommend and develop site specific nutrient management strategies considering the cropping system as

a whole, instead of component crops in isolation [8]-[13]. To achieve this, we have to take into account the direct as well as residual effect of fertilizer to different crops in the system. Integrated plant nutrient system has assumed a great importance and has vital significance for the maintenance of soil productivity. However, organic manures, particularly farmyard manure (FYM) are important components of integrated nutrient management (INM) not only supply macronutrients but also meet the requirement of micronutrients, besides improving soil health. Boosting yield, reducing production cost and improving soil health are three inter-linked components of the sustainability triangle [2]-[6].

Therefore, the present study was carried out to investigate the effect of different organic materials including FYM, wheat straw and green manure along with inorganic fertilizers on nutrient uptake and productivity of pearlmillet–wheat cropping system.

II. Materials and Methods

Experiment was carried out at CCS Haryana Agricultural University, Hisar during 2009-10. The soil of experiment site was sandy loam in texture. The experiment was laid out in randomized block design with 12 treatments combinations replicated four times. The treatments were: T_1 - control (no fertilizer); T_2 - 50% recommended (RD) NPK to pearlmillet and wheat; T_3 - 50% recommended NPK to pearlmillet and 100% recommended NPK to wheat; T_4 - 75% recommended NPK to pearlmillet and wheat; T_5 - 100% recommended NPK to pearlmillet and wheat; T_6 - 50% NPK + 50% N (farmyard manure) to pearlmillet and 100% recommended NPK to wheat; T_7 - 75% NPK + 25% N (farmyard manure) to pearlmillet and 75% recommended NPK to wheat; T_8 - 50% NPK + 50% N (wheat straw) to pearlmillet and 100% recommended NPK to wheat; T_9 - 75% NPK + 25% N (wheat straw) to pearlmillet and 75% recommended NPK to wheat; T_{10} - 50% NPK + 50% N (*Sesbania* spp.) to pearlmillet and 100% recommended NPK to wheat; T_{11} - 75% NPK + 25% N (*Sesbania* spp.) to pearlmillet and 75% recommended NPK to wheat and T_{12} - farmers' practice. The recommended levels of N and P were 125 and 62.5 kg/ha for pearlmillet and 150 and 60 kg/ha wheat. The farmers' practice based on state average was 116 kg/ha N for pearlmillet. In wheat the farmers' practice based on state average was 138.75 kg/ha for N and 54.75 kg/ha for P. The pearlmillet, variety used was HHB-197 with 5 kg/ha seed keeping intra row spacing of 10 cm and inter row spacing 45 cm. In wheat, variety PBW-502 was sown with 100 kg/ha seed keeping inter row spacing of 20 cm. Pearlmillet was sown on June 21, 2009 and was harvested on September 6, 2009. Similarly, wheat was sown on November 2, 2009 and was harvested on April 11, 2010. The N content in different organic materials was determined and the amount of these materials required for substituting a specified amount of N as per the treatment was calculated. The organic sources of nutrients *viz*., FYM, wheat straw and green manure were incorporated in soil 40, 43 and 36 days before sowing pearlmillet crop. Inorganic fertilizers N and P were applied in the form of urea and DAP, respectively. Recommended package of practices were followed in both the crops for other agronomic operations. The grain and stover/straw yield was recorded after harvesting the crop. The N and P uptake was computed from the data on N and P concentration multiplied by grain /stover/ straw yield. In plant analysis, Kjeldahl method was used for N estimation, Ammonium-vanadomolybdo phosphoric acid yellow method for P estimation and Flame emission spectrometric method was used for analyzing K content [9] respectively.

III. Results and Discussion

A. Effect of INM on Nutrient Uptake and Productivity of Pearlmillet

Maximum uptake of nitrogen, phosphorous and potassium in grain as well as stover was recorded in treatment T_6, which is significantly higher than T_1, T_2, T_3, T_4, T_7, T_8, T_9, T_{10} and T_{12} but statistically at par with T_5 and T_{11} (see Table I). Application of FYM to replace 50% nitrogen improved the nutrient content and uptake in grain. This may be due to more availability of nutrients for longer duration and improvement in soil environment. The integrated nutrient management treatments have positive effect on phosphorus uptake by the pearlmillet crop.

Table I. Effect of different treatments on Nitrogen, Phosphorus, Potassium uptake and productivity of Pearlmillet.

Treatments	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)		Yield (kg/ha)	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
T_1	12.62	11.45	0.69	4.99	2.63	61.15	1018	2862
T_2	30.24	25.35	1.99	11.34	7.35	132.33	2348	4637
T_3	33.27	28.37	2.38	12.64	8.72	143.12	2506	6515
T_4	39.83	33.16	2.97	16.10	11.08	170.09	2967	7402
T_5	49.94	42.80	4.18	22.62	3.74	206.28	3472	8538
T_6	53.10	47.02	4.54	25.00	16.11	228.01	3644	9025
T_7	49.27	35.91	3.60	19.25	12.90	206.05	3356	8272
T_8	38.20	27.40	2.44	16.60	9.47	159.04	2884	7070
T_9	42.68	29.79	3.18	18.18	10.53	174.44	3028	7508
T_{10}	47.63	34.46	3.77	20.04	13.29	186.15	3364	7935
T_{11}	50.19	39.97	4.08	22.19	14.39	203.31	3482	8602
T_{12}	39.88	28.83	2.85	17.43	10.35	175.24	2993	7596
SEm ±	**1.92**	**1.91**	**0.17**	**0.74**	**0.95**	**5.43**	**70.12**	**182.44**
CD(P=0.05)	**5.54**	**5.53**	**0.50**	**2.15**	**2.75**	**15.68**	**208.54**	**541.89**

Such types of results have been reported by Satyajeet and Nanwal [16]. The addition of organic matter resulted in the increased NPK content and ultimately the total uptake because addition of organic sources of nutrients (FYM, wheat straw and green manure) resulted in solubilization of insoluble phosphate and higher availability of plant nutrients [5]. The availability of NPK increased by the addition of FYM and thus total uptake is increased. Increases in total uptake by addition of organic sources with inorganic sources have also been reported by Maitra *et al.* [4]. Similar findings have been reported by Kumar *et al*. [10], who reported that amount of nitrogen, phosphorus and potassium declined in plots where these fertilizers were not applied. Treatment T_6 recorded 258 and 22% highest (3644 kg/ha) grain yield over T_1 (control) and T_{12} (farmers' practice) and significantly better over rest of the other treatments except T_5 and T_{11}. Similarly stover yield was also recorded highest in treatment T_6 and corroborative findings have also been reported by Dahiya *et al.* [5]. These two parameters also increased with higher doses of inorganic fertilizers. This might be due to easy availability of plant nutrients and higher photosynthetic activities as compared to under dose fertilized treatments. Replacement of 50% nitrogen through FYM also results into higher grain and stover yields of pearlmillet. This increase in stover probably came through favourable influences on vegetative growth. The results are in conformity with those of Kumar *et al*. [10] who reported that in total production of the system only FYM could replace 50% nitrogen need of pearlmillet without much adverse effect on its production.

Table II. Effect of different treatments on Nitrogen, Phosphorus, Potassium uptake and productivity of Wheat

Treatments	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)		Yield (kg/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	18.63	4.32	2.96	0.93	3.72	20.43	1106	1247
T_2	67.99	15.16	10.98	3.43	14.23	116.02	3812	4270
T_3	102.19	24.71	16.53	5.45	21.84	46.02	5418	6216
T_4	88.11	19.19	13.80	4.48	19.90	93.30	4716	5287
T_5	111.85	27.92	17.99	7.26	27.91	129.53	5738	6452
T_6	118.46	29.10	21.43	8.08	31.93	135.00	5922	6617
T_7	92.05	21.99	16.01	5.97	21.82	111.97	4933	5538
T_8	103.89	24.82	19.34	6.44	23.48	125.68	5564	6260
T_9	88.19	20.43	14.63	5.25	20.42	105.07	4772	5381
T_{10}	112.61	27.88	18.82	6.93	27.07	130.64	5767	6466
T_{11}	88.46	22.87	15.20	5.53	23.41	106.04	4784	5409
T_{12}	87.57	25.36	15.48	5.54	21.18	122.50	5256	6155
SEm ±	**3.09**	**1.27**	**0.92**	**0.40**	**1.71**	**3.41**	**73.12**	**78.45**
CD(P=0.05)	**8.94**	**3.68**	**2.67**	**1.17**	**4.94**	**9.87**	**217.42**	**225.23**

B. Effect of INM on Nutrient Uptake and Productivity of Wheat

Maximum uptake of nitrogen, phosphorous and potassium in grain as well as straw was recorded in treatment T_6 (50% NPK + 50% N (FYM) to pearlmillet and 100% recommended NPK to wheat), which is significantly higher than T_1, T_2, T_3, T_4, T_7, T_8, T_9, T_{11} and T_{12} but statistically at par with T_5 and T_{10} in wheat (see Table II). In wheat, treatment T_6 was recorded 435 and 12% higher grain yield over T_1 (control) and T_{12} (farmers' practice) respectively, indicating that 50% N can be supplemented through FYM in pearlmillet-wheat cropping system. Maximum yield in treatment T_6 might be due to more availability and uptake of nutrient, so that more growth and development of the plant. Minimum yield in control might be due to no nutrition, minimum uptake of NPK, poor growth of the plant. Phosphorus uptake in grain as well as in straw was higher in INM treatments. This might be due to more availability of these nutrients and consequently higher absorption because of increase in root cation exchange capacity. The above findings can be explained on the basis of the fact that nitrogen being a constituent of protoplasm increased the photosynthetic products and meristematic activities. It might have helped in increased uptake of essential plant nutrients like phosphorus, potassium etc. through better root ramification. The nitrogen utilization might have also been affected favourably by phosphorus application. The beneficial effect of fertilizer on grain yield has also been reported by Sammauria and Yadav [12].

IV. Conclusion

Highest yield of both the crops in pearlmillet-wheat cropping system can be obtained with the application of 50% RD-NPK + 50% N through FYM to pearlmillet and 100% recommended dose of NPK to wheat. More nutrient uptake in grain and stover/ straw in pearlmillet-wheat cropping system can be obtained by incorporation of FYM with inorganic fertilizers in comparison to sole application of inorganic fertilizers. 50% nitrogen in pearlmillet grown in sequence with wheat could be substituted by one or more organic sources of nutrients such as FYM, wheat straw or green manure for higher system productivity as well as nutrient uptake by sink.

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