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Response of Integrated Nutrient Management on Growth and Yield of Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz.]-Wheat (*Triticum aestivum* L.) Cropping System

Amit Kumar*, Mukesh Kumar and Naresh Kumar

Department of Agronomy, CCS Haryana Agricultural University, Hisar-125004, India
**Corresponding author*

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A B S T R A C T

A field experiment was undertaken to study the Response of Integrated Nutrients Management on Growth and Yield of Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz.]-Wheat (*Triticum aestivum* L.) cropping system. The investigation was carried out at Research Farm of Department of Agronomy CCS Haryana Agricultural University, Hisar during 2009-10 consisting of 12 treatment combination *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 laid out in randomized block design. Results of the experiment revealed that plant height and dry matter accumulation was maximum in Treatment T_6 which is significantly higher than inorganic treatments T_1, T_2 and T_3 in pearlmillet and wheat but statistically at par with integrated treatments T_5 and T_{10} in wheat and T_5 and T_{11} in pearlmillet. Similarly, 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 other treatments in both the crops.

Introduction

Fertilizer (nutrient) is the key element that can be effectively managed to get desired use efficiency under a given situation. Higher food production needs higher 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. To avoid wastage of resources and to minimize the environmental damage there is a need to develop and demonstrate balanced use of organic/inorganic fertilizers. This will not only improve the crop production in sustainable way but also economise the crop production.

As no single source is capable of supplying the balanced amount of nutrients, integrated use of all sources is a must to supply balanced nutrients to plants (Hedge and Babu, 2004). Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz.]-wheat (*Triticum aestivum* L.) is one of the important cropping systems of the country and spreads over (i) arid eco-region comprising, western plains, Kachh and parts of Kathiawar Peninsula having desert and saline soils representing Gujarat, Rajasthan and Haryana; (ii) semi-arid eco-region comprising northern plains of Haryana, western Uttar Pradesh and central high lands of Rajasthan with alluvium derived soils.

During 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 comprising 17.37 mt of nitrogen, 6.98 mt of phosphorus and 2.4 mt of potash. Consumption of fertilizers (all nutrients) per hectare increased from 1.0 kg to 150.5 kg in 2014-15 (Anonymous, 2016). Long term studies being carried out at several locations on different cropping systems indicated that application of all the needed nutrients through chemical fertilizers has deleterious effect on soil health, leading to unsustainable yields (Swarup, 2002 and Behra *et al.*, 2007). This further has led to aggravated micro-nutrient deficiency in soil system. 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 favorable effect on soil environment and correct marginal deficiency of secondary and micro-nutrients and enhance efficiency of applied nutrients. Therefore, there is need to improve nutrient supply system for sustainable production of this very important cropping system of India.

Materials and Methods

The field experiment was carried out in permanent laid out research plots in Agronomy Research Area 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 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, respectively, before sowing pearmillet crop. The recommended N and P were applied through urea and DAP, respectively. Three post sowing irrigations were applied in pearlmillet. Similarly in wheat four irrigations were applied. 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.

Results and Discussion

Growth and development is a physiological phenomenon of plant life. The rate and amount of growth has a very considerable effect on ultimate yield of plant. The yield of any crop species depends on the source and sinks relationship and on different components of sink itself *viz*., effective tillers, length of earhead, 1000-grain weight etc. Source components may be plant populations, plant height, total tillers and dry matter accumulation of plants before anthesis.

Effect of different treatments on Pearlmillet

The results of the study (Table 1) revealed that growth characters like plant height, total tillers/plant and dry matter accumulation at harvest were highest in treatment T_6 (50% RD-NPK + 50% N through FYM in pearlmillet and 100% RD-NPK in wheat). Treatment T_6 recorded 49% taller plants over control. Treatment T_6 recorded 11% higher total tillers over treatment T_{12} (farmers' practice). Dry matter in treatment T_6 was also 7% higher over treatment T_{12}. Dry matter accumulation at harvest increased significantly with increasing dose of inorganic fertilizers. Treatment T_5 (100% recommended NPK to pearlmillet and wheat) recorded 115, 53, 37 and 18% higher dry matter accumulation over treatments T_1, T_2, T_3 and T_4, respectively.

Supplying full dose of recommended nutrients through inorganic sources provide these in readily available form to the crop. This is in agreement with the findings of Kundu *et al.*, (2006) and Dahiya *et al.*, (2008), who also reported higher response to inorganic sources than to organic sources. The results of the study revealed that treatment T_6 recorded 258 and 22% highest (3644 kg/ha) grain yield of pearlmillet over treatments T_1 (control) and T_{12} (farmers' practice) and significantly better over rest of the other treatments except treatments T_5 and T_{11}. Similarly stover yield was also recorded highest in treatment T_6. Pronounced response obtained through the application of FYM in growth characters might be attributed primarily to the enriched supply of essential nutrients and enhanced availability of native phosphorus. The CO_2 produced during the mineralization of organic matter plays important role in the solubilization of native phosphorus. FYM might also have resulted in the formation of phospho-humic complexes which are more

easily absorbed by plants or the isomorphous replacement of phosphate ions by humate ions and coating of sesquioxide particles by humus to form a protective cover which reduces the phosphate fixing capacity of soil and thus increases its availability.

Table.1 Effect of different treatments on growth parameters and productivity of pearlmillet

Treatments	Plant height at harvest (cm)	Effective tillers/plant at harvest	Dry matter accumulation at physiological maturity (g/plant)	Grain yield (kg/ha)	Stover yield (kg/ha)
T_1	153.3	2.80	52.2	1018	2862
T_2	199.8	3.03	73.3	2348	4637
T_3	211.5	3.23	82.0	2506	6515
T_4	216.4	3.53	95.5	2967	7402
T_5	223.5	4.08	112.3	3472	8538
T_6	225.0	4.18	114.9	3644	9025
T_7	222.9	4.04	111.9	3356	8272
T_8	214.7	3.34	82.6	2884	7070
T_9	218.8	3.75	102.4	3028	7508
T_{10}	222.3	3.85	108.2	3364	7935
T_{11}	224.3	4.11	113.2	3482	8602
T_{12}	220.3	3.78	107.2	2993	7596
SEm ±	**4.17**	**0.13**	**1.21**	**70.1**	**182.4**
CD (P=0.05)	**12.1**	**0.39**	**3.50**	**208.5**	**541.9**

Table.2 Effect of different treatments on growth parameters and productivity of wheat

Treatments	Plant stand at 20 DAS	Plant height at harvest (cm)	Effective tillers/ meter row length	Dry matter accumulation at harvest (g/plant)	Grain yield (kg/ha)	Straw yield (kg/ha)
T_1	36.12	61.1	54.1	54.8	1106	1247
T_2	40.25	92.1	82.3	168.8	3812	4270
T_3	42.26	102.9	102.9	237.3	5418	6216
T_4	41.04	97.8	90.8	204.8	4716	5287
T_5	42.88	104.4	104.7	243.0	5738	6452
T_6	43.12	106.2	105.4	244.9	5922	6617
T_7	41.75	100.9	98.8	223.0	4933	5538
T_8	42.52	103.2	103.1	240.3	5564	6260
T_9	40.20	98.9	96.7	212.2	4772	5381
T_{10}	43.00	105.8	105.5	243.6	5767	6466
T_{11}	41.22	100.0	98.0	220.2	4784	5409
T_{12}	42.02	101.4	100.7	232.2	5256	6155
SEm ±	**2.11**	**0.84**	**1.40**	**0.67**	**73.1**	**78.4**
CD (P=0.05)	**NS**	**2.46**	**4.15**	**1.96**	**217.4**	**225.2**

Effect of different treatments on wheat

Plant stand was not affected by different treatments (Table 2). Maximum grain yield (5922 kg/ha) and straw yield (6617 kg/ha) 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_{11} and T_{12} but statically at par with T_5 and T_{11}. Treatment T_6 recorded 435 and 12% higher grain yield and 430 and 8% higher

straw yield over control and farmers' practice, respectively, indicating that 50% N can be supplemented through FYM in pearlmillet-wheat cropping system. The highest grain yield in treatment T_6 is being supported by growth and yield contributing characters. Tallest plant was recorded in T_6. Similarly, maximum no. of effective tillers/meter row length and dry matter accumulation was recorded in T_6 which is statistically at par with T_5 and T_{10} but significantly superior to rest of the treatments and 95 and 347% higher over control, respectively. The results are in confirmation to the findings of Katyal *et al.*, (2002) and Jain and Poonia (2003).

Experiment concluded that the integrated nutrient management in pearlmillet-wheat cropping system have positive effect on growth parameters and ultimately on yield. Highest yield of both pearlmillet and wheat 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.

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