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Effect of biofertilizers and inorganic nutrients management on the productivity and soil properties of setaria (*Setaria anceps* Stapf.) – white clover(*Trifolium repens* L.) system under sub-temperate climatic conditions

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Abstract
An experiment was conducted at Fodder Farm of Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh (India) for five years to evaluate the effect of biofertilizers and nutrient management on the productivity and soil properties of setaria grass (*Setaria anceps*) – white clover(*Trifolium repens* L.) system under sub-temperate climatic conditions. The experiment was laid out in a randomized block design with three replications and comprised of seven treatments *viz.*, T_1- Control (no use of biofertilizers and NPK), T_2- Biofertilizer (*Azotobactor*in setaria/*Rhizobium*in white clover), T_3- 50% NPK through inorganic fertilizer, T_4- Biofertilizer (*Azotobactor* in setaria/*Rhizobium*in white clover)+50% NPK through inorganic fertilizers, T_5- 75% NPK through inorganic fertilizers, T_6- Biofertilizers (*Azotobactor* in setaria/*Rhizobium*in white clover)+75% NPK through inorganic fertilizer, T_7- 100% NPK through inorganic fertilizer.Application of biofertilizers along with NPK through inorganic fertilizers proved better for sustaining round the year forage production. Significantly higher green and dry fodder yieldsof both setaria and white clover was obtained with combined application of biofertilizers and 75% of recommended NPK through inorganic fertilizers. Application of biofertilizers and 75% of recommended NPK through inorganic fertilizers resulted in better system productivity and economic returns while, application of sole biofertilizers gave maximum benefit cost ratio. Application of 100% of recommended NPK resulted in betterbuildup of available soil nitrogen, phosphorus and potassium while application of biofertilizers with 75% of recommended NPK through inorganic fertilizers improved soil organic carbon, cation exchange capacity and pH over initial values.

Keywords: Biofertilizers, setaria grass, white clover, green and dry fodder yields

Introduction
Livestock have important role in overall growth of agriculture and gross domestic product (GDP) of Indian economy. In India, Total livestock population increased to 536.76 million from 512.05 million during the period of 2012 to 2019 with an increase of 4.8 per cent. Rural areas account for 95.75 per cent of total livestock population (Anonymous, 2019) [2]. Available fodder sources *viz.;* cultivated fodder crops, pastures and grasslands, crop residues, fodder trees and cultivable wastelands etc. are not sufficient to meet the fodder requirement of livestock in the country It is estimated that by 2050 the demand for green fodder will reach to 1012 million tonnes and current level of growth in forage resources a deficit of 18.4% in green fodder and 13.2% in dry fodder by 2050 (Anonymous, 2015) [3]. In the country fodder crops occupy 5 per cent of grossed cropped area and it is static since last few decades (Roy *et al.* 2019) [17]. The situation in hilly areas states of north-western Himalayas is more worse. In the region farming is dominated by small and marginal farmers and fodder cultivation is their least priority as their focus is on grain crops, pulses and some cash crops (Kumar *el al.* 2019) [10]. Hence, Improvement in forage production and productivity per unit land area along with fodder grasses and legumes could be a breakthrough to address this problem (Kumar *et al.* 2012) [11]. Several directions have been proposed to move towards sustainable forage production *i.e.* agroecology, ecological intensification, eco-efficient agriculture and sustainable intensification (Martin *et al.* 2020) [12].

Setaria(*Setaria anceps* Stapf.) a perennial grass used as soilage, hay and grazing as well, has good digestibility, palatability and is a good source of crude protein (11.5%), neutral detergent fibre (NDF, 75.5%), acid detergent fibre (ADF, 40.8%) and improves the animal performance

(Jank *et al.* 2007) [9]. This grass has varied range of adaptability among all the tropical grasses and can perform well in high rainfall areas (900-1285 mm) and can also withstands in drought and longer flooding as well (TOF, 2019) [19]. White clover (*Trifolium repens* L.) a stoloniferous perennial legume is most important forage in temperate and sub-temperate zones and contributes to a more sustainable forage production system (Elgersma and Hassink, 1997) [6]. Grasses and legume mixture appear a viable option for producing quality fodder for the livestock. Use of biofertilizer in forage based system could be viable options to sustain both yield and quality of forages as well as minimum the use of inorganic fertilizers. Root dipping of perennial grasses and seed treatment of legumes with biofertilizers ensure better establishment and survival of species under varied growing conditions and better yield of forage crops (Parera and Cantliffe, 1994) [14]. The information on performance of setaria grass-white clover system under biofertilizers and nutrient management is not available. Therefore, study was undertaken to find out the suitability of nutrient management practices on the productivity of setaria grass-white clover system as well as soil properties.

Materials and methods

An experiment was conducted at Fodder Farm of Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh (India) for five years. Geographically, the experimental site was located at 32º 6' N latitude and 76º 3' longitude at an elevation of 1290.8 m mean sea level in North-Western Himalayas. Agro-climatically experimental site falls under sub-temperate and sub-humid zone, characterized by high annual rainfall (2200-2500 mm) with mild summers (19-31 ºC) and extreme winters (3.5-1.4 ºC). The experiment was laid out in a randomized block design with three replications andcomprised of seven treatments *viz.*, T_1- Control (no use of biofertilizers and inorganic fertilizers), T_2- Biofertilizer (*Azotobacter* in setaria/*Rhizobium* in white clover), T_3- 50% NPK through inorganic fertilizer, T_4- Biofertilizer (*Azotobacter* in setaria/*Rhizobium* in white clover) + 50% NPK through inorganic fertilizers, T_5- 75% NPK through inorganic fertilizers, T_6- Biofertilizers (*Azotobacter* in setaria/*Rhizobium* in white clover) + 75% NPK through inorganic fertilizer, T_7- 100% NPK through inorganic fertilizer. Setaria grass rooted plant slips were dipped for half an hour in *Azotobacter* culture and thereafter planted in *Kharif* season at 40 x 40 cm crop geometry and was maintained to end of the experiment. White clover seeds were treated with *Rhizobium* culture following standard procedure of seed inoculation and sown in between the setaria grass using seed rate of 6 kg/ha. Bio-inoculants *i.e. Azotobacter* for setaria and *Rhizobium* for white clover were applied in year of establishment. Recommended N, P and K was 120, 60 and 40 kg/ha for setaria grass and 20, 60 and 40 kg/ha for white clover were applied through urea, single super phosphate and muriate of potash. First year was considered as the year of establishment of crops and in subsequent years four cut of setaria grass during *Kharif* season and three cut of white clover during *Rabi* season were taken in each year. Herbage yield of all the cuts was sum up for each crop and expressed as total yield of crop. Fresh samples were oven dried at 72 ºC till constant weight was obtained and dry matter content was used to obtained dry matter yield in each treatment. The gross returns, net returns and benefit cost ratio (B:C) of different treatments was computed based on cost of various inputs and price of output. Before the start of experiment composite soil sample and after the completion of the experiment treatment wise soil samples at 0-15 cm depth were collected from the experiment field. The soil samples were dried, ground, passed through 2 mm sieve and analyzed for various soil physico-chemical properties following standard procedures.Data followed the homogeneity test, hence pooling was done over the seasons and mean data has been presented. Data collected on various parameters were statistically analyzed following the standard analysis of the variance technique (ANOVA) as described by Gomez and Gomez (1984) [7].

Result and Discussion

Green Fodder Yield

Green fodder yield of setaria grass and white clover as well as total system productivity was significantly increased by different treatments over control (Table 1). Application of biofertilizers+75% of recommended NPK through inorganic fertilizers proved more efficient to sustain the forage yield and produced significantly higher green fodder yield of setaria, white clover and total green fodder of the system, but remained statistically at par with the application of 100%recommended NPK through inorganic fertilizers, 75% recommended NPK through inorganic fertilizers and application of biofertilizer+50% recommended NPK through inorganic fertilizers. Application of 75% recommended NPK through inorganic fertilizers, 100% recommended NPK through inorganic fertilizers,biofertilizer+50% recommended NPK through inorganic fertilizers and biofertilizers+75% of recommended NPK through inorganic fertilizers produced 30.81%, 31.90%, 29.97% and 37.48% more total green fodder yield of system over control, respectively. Application of biofertilizers+50% recommended NPK through inorganic fertilizers produced total green fodder yield equal to application of 75% recommended NPK through inorganic fertilizers and integration of biofertilizers and 75% recommended NPK through inorganic fertilizers produced more total green fodder yield than application of 100% recommended NPK through inorganic fertilizers. Improvement in green fodder yield with the application of biofertilizers might be due to favorable environment in rhizosphere for better expression of physiological growth parameters. *Azotobacter* and *Rhizobium* fixed atmospheric nitrogen through asymbiotic and symbiotic mechanism, respectively which ultimately reflect into higher green fodder yield. *Azotobacter* and *Rhizobium* also known to promote root growth of crops and results in more above ground dry matter of crops. Chaichi *el al.* (2015) [4] observed significant increase in green forage yield of berseem with combined application of biofertilizer and inorganic fertilizers. Similarly, better effect of biofertilizers and inorganics integration on productivity of forage crops were also reported by Aditi *et al*. (2019) [1]; Patel *et al*. (2018) [15] and Patidar and Mali, (2004) [16].

Dry Fodder Yield

Integrated nutrient management *i.e.* biofertilizers+inorganic fertilizers had significant effect on dry fodder yield of setaria grass- white clover forage system (Table 1). Combined application of biofertilizer+75% of recommended NPK through inorganic fertilizers appeared efficient for sustaining yield over the period and recorded significantly higher dry fodder yield of setaria grass, white clover as well as total system productivity and remained statistically at par with the application of 100% recommended NPK through inorganic fertilizers 75% recommended NPK through inorganic fertilizers and combined application of biofertilizer+ 50% of recommended NPK through inorganic fertilizers. The magnitude of increase in total dry fodder yield of system was 32.20%, 34.62%, 35.94% and 40.34% with the application of biofertilizers+50% recommended NPK through inorganic fertilizers, 75% recommended NPK through inorganic fertilizers, Biofertilizers+75% recommended NPK through inorganic fertilizers, 100% recommended NPK through inorganic fertilizers and biofertilizers+75% recommended NPK through inorganic fertilizers over control, respectively. Integration of biofertilizers and75% recommended through inorganic fertilizers produced 6.86% more total green fodder yield over 100% recommended NPK through inorganic fertilizers. The improvement in morphological growth attributes by biofertilizer and inorganic fertilizer application might have resulted in better interception and utilization of radiant energy leading towards higher photosynthesis and finally more accumulation of dry matter of individual plants. The results are in close proximity of Singh *et al*. (2005) [18]. Meena *et al.* (2013) [13]; Deva (2015) [5] and Verma *et al.* (2016) [20], who reported about the positive effect of biofertilizers with chemical fertilizers in increasing dry matter accumulation in different fodder crops.

Economics

The economic indicators *viz.;* gross returns, net returns and B:C ratio have a great impact on practical utilization and acceptance of any technology. The effect of different treatments on the economic indicators (Table 3) revealed highest gross and net returns were with the combined application of biofertilizer+75% of recommended NPK through inorganic fertilizers however, maximum B:C was obtained with the application of sole biofertilizers. Increase in gross returns and net returns were mainly attributed to higher green forage yield while lower cost of cultivation with sole biofertilizers reflected its effect on higher B:C in this treatment.

Soil Properties

The data on soil physico-chemical properties (Table 4) indicated buildup of available soil nitrogen, phosphorus and potassium, soil organic carbon and improvement in cation exchange capacity (CEC) and soil pH over initial value in all treatments except control. Maximum buildup in available soil nitrogen, phosphorus and potassium was observed with the application of 100% recommended NPK through inorganic fertilizers while maximum improvement in soil organic carbon, cation exchange capacity and soil pH were observed with combined application of biofertilizers+75% recommended NPK through inorganic fertilizers followed by sole biofertilizer application. The more increment of soil organic carbon over initial value in fertilized plots as compare to control might be due to application of biofertilizers in fertilized plots increased the microbial population and results in more soil aggregation and decomposition lead to build up of organic carbon in soil. Similar results were also reported by Gundler *et al*. (2015) [7].

Table 1: Effect of different treatments on green fodder and dry fodder yields of setaria grass-white clover system

Treatment	Green fodder yield (q/ha)			Dry fodder yield (q/ha)		
	Setaria	White clover	Total	Setaria	White clover	Total
T_1- Control (no use of biofertilizers and NPK)	222.72	71.51	294.22	40.47	13.40	48.81
T_2- Biofertilizer (*Azotobacter/Rhizobium*)	251.14	82.92	334.06	46.67	15.60	55.03
T_3- 50% NPK through inorganic fertilizer	270.77	95.94	366.72	50.12	19.09	63.13
T_4- Biofertilizer (*Azotobacter/Rhizobium*) + 50% NPK through inorganic fertilizers	288.77	113.87	402.64	54.29	21.12	71.99
T_5- 75% NPK through inorganic fertilizers	303.90	121.77	425.66	55.78	22.94	74.66
T_6- Biofertilizers (*Azotobacter/Rhizobium*) + 75% NPK through inorganic fertilizer	328.06	142.56	470.61	60.88	26.74	81.81
T_7- 100% NPK through inorganic fertilizer	307.90	124.11	432.01	56.64	23.79	76.20
SEm$\pm$	18.75	9.56	22.63	2.26	1.89	3.34
CD5%	55.75	29.35	69.45	6.95	5.80	10.28

Table 2: Effect of different treatments on economics and resources use efficiency of setaria grass-white clover cultivation

Treatment	Cost of cultivation (Rs. /ha)	Gross returns (Rs. /ha)	Net returns (Rs. /ha)	B:C
T_1- Control (no use of biofertilizers and NPK)	13757	34475	20718	1.47
T_2- Biofertilizer (*Azotobacter/Rhizobium*)	14058	38372	24314	1.74
T_3- 50% NPK through inorganic fertilizer	18172	42163	23991	1.33
T_4- Biofertilizer (*Azotobacter/Rhizobium*) + 50% NPK through inorganic fertilizers	19145	46673	27528	1.47
T_5- 75% NPK through inorganic fertilizers	20955	49579	28624	1.40
T_6- Biofertilizers (*Azotobacter/Rhizobium*) + 75% NPK through inorganic fertilizer	22207	55234	33027	1.52
T_7- 100% NPK through inorganic fertilizer	22184	50154	27969	1.30

Table 3: Effect of different treatments on soil properties of setaria grass-white clover system

Treatments	pH	N (kg/ha)	P (kg/ha)	K (kg/ha)	OC %	CEC C mol (P^+) kg^{-1}
T_1- Control (no use of biofertilizers and NPK)	5.6	201	5	245	0.56	11
T_2- Biofertilizer (*Azotobacter/Rhizobium*)	5.6	226	6	275	0.58	12
T_3- 50% NPK through inorganic fertilizer	5.7	228	8	272	0.56	13
T_4- Biofertilizer (*Azotobacter/Rhizobium*) + 50% NPK through inorganic fertilizers	5.6	215	9	268	0.57	11
T_5- 75% NPK through inorganic fertilizers	5.8	316	13	325	0.56	12
T_6- Biofertilizers (*Azotobacter/Rhizobium*) + 75% NPK through inorganic fertilizer	5.6	325	13	330	0.59	12
T_7- 100% NPK through inorganic fertilizer	5.7	335	16	351	0.58	12
Initial value	5.6	225	8	285	0.56	10

Conclusion

The study conclusively indicated that integration of biofertilizers with chemical fertilizers appeared suitable nutrient management system to sustain the productivity of setaria grass-white clover forage system with improvement in physico-chemical properties of soil.

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