Optimizing Production Technology for Sustainable Organic Fodder Production and Soil Health in Indo-Gangetic Plains of India

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Abstract

Field experiment was carried at Instructional Dairy Farm, G B Pant University of Agriculture & Technology, Pantnagar (India) during 2020-21 and 2021-22 to optimize the production technology for sustainable organic fodder production and soil health in Indo-Gangetic plains of India. Among the organic production systems, application of vermicompost @ 5 t/ha gave the highest fodder yield, gross return and net return but the B:C ratio was derived highest from zero budget natural farming. Among the *Kharif* crops grown in different cropping systems, BN hybrid intercropped with cowpea gave the significant higher green and dry fodder yield, gross return, net return as well as B:C ratio. Therefore the BN hybrid intercropped with cowpea may be grown under zero budget natural farming for higher fodder productivity and B:C ratio in whole Indo Gangetic plains of India and may be replicated in similar ecologies.

Introduction

India is an agrarian country but animal husbandry has been traditionally an integral part of rural economy (Dagar 2017) and it directly affects the livelihood and food security of nearly 1 billion people around the world (Downing *et a*l 2017). According to the 20th Livestock census-2019, India's total livestock population is 535.82 million that is 4.6% higher than previous census-2012. On other hand, only 4.2% the country's cropped area is under fodder crops and it has been static for many years (Dar *et al* 2006), therefore, the projected availability of fodder supply has been dropped from 60 in 1990 to presently 50%. Currently the shortfall in availability of green and dry fodder and also concentrates in India is 35.6, 10.95 and 44%, respectively (IGFRI Vision 2050). In present scenario, there is hardly any scope of area expansion under forage crops mainly because of pressure of food and cash crops, so the vertical expansion including yield enhancement as well as exploring the new area like marginal, fallow and uncultivated forest area i.e.11% of total geographical area of India is essentially required. On other hand, an imbalanced use of chemicals in agriculture has degraded our production ecologies resulting into degradation of soil, water resources, food quality, crop productivity and farm profitability (Onte *et al* 2019). These adverse effects on human and animal health as well as environment have renewed the interest in organic farming worldwide. In India too, the demand of organic milk and milk products like organic ghee, paneer, cheese, curd etc., has increased many folds and it requires intensifying the research base on organic fodder production.

Organic nutrient management is the basic need for organic crop production. Recently various organic sources of nutrients like FYM, vermicompost, biofertilizers, plant growth promoting rhizobacteria (PGPR), green manures, panchagavya, amritpani, jivamrit, ghanjivamrit, brahmashastra, herbal kunapjal, gloria biosol etc. are used for balanced plant nutrition in different forms of organic farming like 'zero budget natural farming, biodynamic agriculture, rishi krishi, panchgavya krishi, natural farming and natueco farming. Organic farming is considered an efficient alternative to traditional farming for sustainable agriculture with free from chemicals. Besides, it is an eco-friendly, economically viable, ecologically sound and also plays a significant role in the improvement of soil physio-chemical and biological properties of soil.

The organic bio-enhancers increased soil fertility by improving the activity of soil micro-flora and fauna. Xu and Xu (2000) reported the presence of naturally occurring beneficial effective micro organisms (EMO's) like lactic acid bacteria, yeast, *Actinomycetes*, photosynthetic bacteria and certain fungi besides beneficial and proven fertilizers such as Acetobacter, Azospirillum and Phosphobacterium in panchagavya which had the beneficial effect especially in improving soil quality, growth and yield of crops. Similarly, Govindaraju and Reddy (2011) found increment in the population of phosphorus solubilising bacteria *Azospirillum, Azotobacter, Rhizobium and PSB* after three years of conversion to organic farming. The N, P and K uptake of maize was higher than control with residual soil fertility of FYM application (Choudhari

and Kumar 2013) mainly because of decreased bulk density, improved water holding capacity of soil (Sharma and Gupta 1998). Similarly the foliar application of panchagavya and neem leaf extract gave higher N, P and K content and uptake in spinach followed by treatment panchagavya + glyricidia leaf extract in spinach (Shinde 2018).Considering the above facts of organic farming, the present investigation was carried out with objective to optimize the production technology of sustainable organic fodder production and soil health in Indo-Gangetic plains of India.

Methods and Materials

Field experiment was carried at Instructional Dairy Farm, G B Pant University of Agriculture & Technology, Pantnagar (India) during 2020-21 and 2021-22 to optimize the production technology for sustainable organic fodder production and soil health in Indo-Gangetic plans of India. The experiment site was silty clay loam in soil texture with 7.16 soil pH, 0.190 ds/m EC and available organic carbon, nitrogen, phosphorus and potassium was 0.74%, 282.51, 2816 and 235.00, respectively. The experiment consisted of 4 organic production systems in main plots i.e. '*Vermicompos*t' (VC) @ 5 t/ha, '*Zero Budget Natural Farming(ZBNF)'* (seed treatment with Bijamruta followed by (soil treatment and foliar spray with 'Jivamruta'@(3% at 20 days after sowing and after each cut), '*Panchgavya Krishi'* (foliar spray of Panchgavya@ 3% at 20days after sowing and after each cut) and '*Rishi Krishi* (Application of 'virgin soil' (3%) before sowing followed by foliar spray of 'A*mritpani' @ 3% at 20 days after sowing followed by each cut)* and 03 cropping systems i.1. 'sorghum – berseem - maize + cowpea', B N hybrid + (cowpea-berseem-ricebean) and 'maize (sweet corn) - berseem+mustard - maize (sweet corn) was laid out in Split plot design with three replications. The B N hybrid was planted at 70cmx40cm planting geometry while all other crops were maintained at 30cmx10cm spacing. The B N hybrid was intercropped with cowpea, berseem and ricebean during *Kharif*, *Rab*i and summer season The growth and yield attributes including plant height, dry matter, leaf-stem ratio, green fodder dry fodder, economics and residual soil health were studies. Among the crops of different cropping systems, 1st crop was sown in *Kharif* season (June-Sept-October), 2nd crop in Rabi season (October-November to March-April) and 3rd crop in summer season (April-May to June –July). The variety of the crops were Pant B N hybrid (BN Hybrid), UC 268 (Cowpea), Mescavi (berseem), Sugar-75 (maize-sweet corn) and Kiran (mustard).The 'kunaljal', a bioenhencer as well as an important agent for plant protection was used to control pest and diseases whenever required. The experiment results of two Kharif seasons i.e. 2020 and 2021 are presented here.

Results and Discussion

a. Effect of organic production system

The plant height, L:S ratio and fodder yield were affected significantly by organic production system (Table.1). The mean of two years revealed that an average plant height was significantly higher under application of vermicompost that was significantly similar to rishi krishi organic production system mainly because of improving water holding capacity of soil and N, P and K uptake (Choudhari and Kumar 2013). The lowest plant height was observed at application of panchgavya followed by zero budget natural farming system. Similarly the highest plant height of intercrop was recorded under vemicompost followed by rishi kridhi system. The number of shoots/plants did not differ significantly among organic production systems however the highest values were under rishi krish followed by Vermicompost. The L:S ratio of main crop as well as intercrop was recorded higher under panchgavya. Swaminathan *et al.* (2007) also observed positive effect of foliar spray of panchagavya @3% on growth and yield of black gram. The green and dry fodder yield of both main and intercrops were recorded significantly higher under vermicompost that was non-significant with rishi krishi system. Khan *et al.* (2008) reported that the use of organic manure (FYM, poultry manure, green leaf on sweet corn field resulted in significant increase of cob and fodder yield. The lowest fodder yields were estimated under Panchgavya followed by ZBNF.

The equivalent green fodder yield was also affected significantly by organic production systems and significantly highest values were obtained at application of vermicompost. The equivalent green odder yield was, however, significantly similar at both zero budget natural farming and rishi krishi. The lowest values were obtained under panchgavya application. The higher equivalent green fodder yield was attributed to higher yield of main and inters crops. Application of vermicompost gave significantly highest gross and net reruns followed by zero budget natural farming, rishi krishi and the lowest under panchgavya but the B:C ratio was significantly highest under zero budget natural farming followed by vermicopost (Table.2). The cost of cultivation was lowest under zero budget natural farming that resulted into higher B:C ratio. Deshmukh *et al.* (2012) reported higher economic returns and B: C of soybean-wheat cropping sequence at application of 100 per cent RDN through vermicompost, FYM and compost along with jivamruta. The soil

quality attributes i.e. bulk density, organic carbon and availability of N, P and K were observed higher under application of vermicompost followed by zero budget natural farming.

b. Effect of cropping system

The plant height of sorghum under sorghum-berseem-maize+cowpea cropping system was significantly highest followed by maize (sweet corn) grown under maize(sweet corn)-berseem+mustard-maize(sweet corn) system. The height of intercrop (cowpea) grown under BN Hybrid +cowpea/ berseem /ricebean was recorded 150cm. The number of shoots/per meter row length was found significantly highest under BN hybrid followed by sorghum. The L:S ratio was also highest in BN hybrid followed by maize (Sweet Corn). The green and dry fodder yield was recorded significantly highest under BN hybrid followed by sorghum. The BN hybrid gave two harvests in *Kharif* season that gave better green and dry fodder yield than maize and sorghum (Table.1).The BN hybrid grown with cowpea produced significantly highest equivalent green fodder yield and also gave highest gross and net returns followed by maize (sweet corn). The B:C ratio was also obtained significantly highest under BN hybrid+cowpea followed by maize (sweet corn) (Table.2). The soil quality attributes i.e. bulk density, organic carbon and availability of N, P and K were found under higher under BN hybrid+cowpea followed by maize (sweet corn).

Table 1. Effect of organic production systems and cropping systems on growth, fodder yield and quality of fodder crops at Pantnagar centre (Pooled of *Kharif* 2020 and 2021)

Treatment	Plant ht (cm)		No of shoots/plant/m row		L:S ratio		Green fodder yield (q/ha)		Dry fodder yield(q/ha)	
	Main crop	Inter crop	Main crop	Inter crop	Main crop	Inter crop	Main crop	Inter crop	Main crop	Inter crop
Organic Production Systems										
Vermicompost (VC)	199	177	25.48	10.33	0.45	0.77	408.35	55.7 (63.07)*	72.89	6.44
Zero budget natural farming	181	117	23.76	09.00	0.41	0.81	352.09	24.53 (53.33)*	61.70	2.86
Panchgavya Krishi	170	142	21.76	08.33	0.48	0.82	279.02	11.37 (40.86)*	51.03	1.39
Rishi krishi	194	158	25.68	09.33	0.44	0.78	379.58	29.57 (45.9)*	68.36	3.63
SEm±	3.68	-	0.87	-	0.01	-	9.53	-	2.17	-
LCD (0.05)	13	-	NS	-	0.03	-	33.62	-	7.64	-
Cropping Systems										
Sorghum-Berseem-Maize+ Cowpea	218	-	15.42	-	0.28	-	305.27	-	61.10	-
BN Hybrid +Cowpea/ Berseem/ Ricebean	164	150	46.01	9.22	0.58	0.80	528.53	30.29	84.78	3.58
Maize(sweet corn) -B+Mustard-Maize(sweet corn)	175	-	11.08	-	0.47	-	230.49	50.79	44.61	-
SEm±	3.41	-	0.60	-	0.01	-	6.92	-	1.42	-
LCD (0.05)	10	-	1.82	-	0.03	-	20.91	-	4.28	-
Interaction	**NS**	-	**S**	-	**S**	-	**S**	-	**S**	-

*Sweet corn yield (q/ha)

Table 2. Effect of organic production systems and cropping systems on equivalent fodder yield and economics of fodder crops at Pantnagar centre (pooled data of *Kharif*-2020 and 2021)

Treatment	Equivalent green fodder yield (q/ha)	Gross return Rs./ha	Net Return Rs./ha	B:C Ratio
Organic Production systems				
Vermicompost (VC)	513.47	102,693	51,704	2.00
Zero budget natural farming	440.98	88,196	47,429	2.16
Panchgavya Krishi	347.13	69,426	28,326	1.66
Rishi krishi	456.08	91,216	43,549	1.90

SEm±	9.40	1,881	1,918	0.04
LCD (0.05)	33.17	6,634	6,766	0.15
Cropping Systems				
Sorghum-Berseem-Maize+Cowpea	305.27	61,053	21,803	1.56
BN Hybrid +Cowpea/ Berseem/Ricebean	528.53	105,705	60,230	2.32
Maize(sweet corn)-B+Mustard-Maize(sweet corn)	484.44	96,722	46,222	1.91
SEm±	6.25	1,249	1,257	0.03
LCD (0.05)	18.88	3,776	3,800	0.09
Interaction	S	S	S	S

Note: Sale rate of green fodder= Rs. 200- per quintal**.**

Conclusion

The experimental results indicate that zero budget natural farming had the highest B:C ratio, however the highest green and dry fodder were recorded at application of Vermicompost but the higher cost of vermicompost lowered the B: ratio. Similarly the intercropping of cowpea with B N hybrid gave the highest fodder yield as well as B:C ratio. Therefore it may be recommended that BN hybrid intercropped with cowpea may be grown under zero budget natural farming for higher fodder yield, net profit and soil health. The intensive organic production system i.e. BN Hybrid+Cowpea/Berseem/Ricebean will not only provide year round organic green fodder but also support organically produced dairy products.

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