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Production efficiency and profitability of forage based cropping systems under mid hills of north-western Himalayas

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Abstract

A field experiment was conducted from *rabi* 2000 to *kharif* 2008 to study the effect of different forage based cropping systems on productivity, sustainability, nutrient use productivity, monetary efficiency and soil properties under mid hill conditions of north-western Himalaya. Eight cropping systems were tested in randomized block design with three replications. Oat (*Avena sativa* L.) + fodder *sarson* (*Brassica rapa* L.) – fodder maize (*Zea mays* L.) + fodder cowpea (*Vigna unguiculata* (L.) Walp.) cropping system resulted in highest green fodder equivalent yield (60.77 t/ha/year) with better production efficiency (166 kg/ha/day) and sustainable yield index (0.99). In terms of net returns, wheat - fodder maize cropping system maintained superiority (Rs.39,676/ha/year) with monetary efficiency of Rs.109/ha/day. Systems comprised of short duration crops and legumes, resulted in improvement in available soil NPK. However, inclusion of sorghum and guinea grass in the cropping system did not improved soil nitrogen status even after the completion of eight crop cycles.

Key words: Cropping systems, fodder yield, monetary efficiency, sustainable yield index, nutrient use efficiency.

Introduction

North western Himalayan region offers good scope for rearing of milch cattle but the weakest link in this direction is the availability of sufficient quantity of qualitative fodder. In state of Himachal Pradesh, the deficit of green and dry fodder has been estimated about 20 and 50 per cent, respectively (Anonymous, 2011). Further, small size land holdings and farmer's preference for grain and cash crops restrict the scope of area expansion under cultivated fodder crops in the region. Therefore, inclusion of fodder crops in the existing cropping systems appears a viable preposition to meet out the fodder requirement of the existing livestock population in the region. Cropping systems comprising botanically diverse species including forage species, appears to be one of the feasible approaches for increasing the herbage production, utilizing land more efficiently and providing stability to production (Tripathi, 1989). Maize – wheat is the traditional cropping system in mid hills of north-western Himalayas. In order to get the best result in terms of forage production by diversification in this existing cropping system, a rational approach is required regarding inclusion of forage species in the system. However, information on effect of forage based cropping systems in the region is not available. Therefore, present study was undertaken to find out the possibility of diversification with forages of traditional maize –

wheat system in view of productivity, sustainability, profitability and soil properties under irrigated conditions.

Materials and Methods

The field experiment was conducted at fodder production and grassland management centre, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, during *rabi* 2000 to *kharif* 2008. The experimental site was characterized by sub-humid sub-tropical climate in the mid hill of north-western Himalaya. The soil was silty clay loam (Typic –Hapludalf), acidic in reaction (pH 5.7), low in organic carbon (0.69%), available nitrogen (290.2 kg/ha), phosphorus (11.03 kg/ha) and potassium (282.16 kg/ha).

Eight cropping systems viz. wheat – maize; oat + fodder sarson – maize; wheat - fodder maize; wheat – guinea grass; wheat – sorghum; oat + fodder sarson – guinea grass + fodder cowpea; oat + fodder sarson – sorghum + fodder cowpea and oat + fodder sarson – fodder maize + fodder cowpea were tested in randomized block design with three replications. All the treatments for eight crop cycles were tested on the same experimental site and plots without changing the layout of the experimental treatments. 'Surbhi' of wheat, 'Girja' of maize, 'SSG hybrid' of sorghum, 'PGG-9' of annual guinea grass, 'PLP-1' of oat, 'Varuna' of sarson and 'Himlobia' of cowpea varieties were grown with recommended packages of practices. Main crops were sown in lines and companion crops as per the treatments were sown by broadcast in the main crops. Rabi crops were sown in mid November and kharif crops were sown in last week of June and crops were harvested as and when they attain the stage of harvesting as per the purpose i.e. fodder or grain. Fertiliser dose of 120 kg N, 60 kg P_2O_5 and 30 kg K_2O with 5 t FYM per hectare on air dry weight basis was applied to both rabi and kharif season crops in each year. Five irrigations during rabi season and three irrigations during kharif season in each year were applied as and when required. For comparison between cropping systems the yield of all systems was converted to oat green fodder equivalent yields based on prevailing prices of each produce. Sustainability yield index (SYI) and production efficiency were worked out as per method of Singh *et al.* (1990) and Reddy *et al.* (1996), respectively. The nutrient use productivity was calculated by dividing the fodder equivalent yield of the system with the total quantity of nutrients (NPK) used in different crops in the system. The soil pH and organic matter content were estimated by the methods of Jackson (1967) and Walkley and Black (1934), respectively, whereas available nitrogen, phosphorus and potassium were determined by the methods described by Subbiah and Asija (1956), Olsen *et al.* (1954) and AOAC (1970), respectively.

Results and Discussion

Cropping system's productivity

The results revealed that there is sufficient scope to replace the maize –wheat cropping system with other sustainable forage based cropping systems without any decline in economic yield. Among cropping systems under evaluation in the present study, oat + fodder sarson – fodder maize + fodder cowpea; oat + fodder sarson – guinea grass + fodder cowpea; wheat - fodder maize; wheat – annual guinea grass and oat + fodder sarson – sorghum + fodder cowpea cropping systems gave 60.77, 56.60, 55.64, 52.33 and 51.22 t/ha/annum green fodder equivalent yield as against 39.85 t/ha/annum in wheat – maize system, that shows the superiority of forage based systems over wheat– maize system (Table 1). The better oat green fodder equivalent yield in the cropping systems under evaluation compared to wheat - maize system may be due to inclusion of fodder crops in these systems, which resulted in higher biomass yield with better economic returns and ultimately in more green fodder equivalent yield.

Among kharif fodder crops maize proved

Table 1. Green fodder equivalent yield, production efficiencies, sustainable yield index, nutrient use productivity and economics of different cropping systems

Cropping systems	Yield (t/ha)		Oat Green fodder equivalent yield (t/ha)			Production efficiency (kg/ha/day)	Sustainable yield Index	Nutrient use productivity (kg fodder/kg nutrient applied)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha/ year)	B:C ratio	Monetary efficiency (Rs./ha/day)
	Rabi	*Kharif*	*Rabi*	*Kharif*	Total							
Wheat-maize	2.52	2.38	19.05	20.80	39.85	109	0.64	94.88	18360	21483	1.19	59
Wheat-fodder maize	2.67	35.22	20.42	35.22	55.64	158	0.93	132.48	15965	39676	2.48	109
Wheat-guinea grass	2.39	33.75	18.58	33.75	52.33	143	0.85	124.59	19420	32900	1.69	90
Wheat-sorghum	2.27	28.27	18.05	28.27	46.32	127	0.75	110.28	18878	27455	1.45	75
Oat+ fodder s*arson* – maize	20.38	2.26	20.38	20.59	40.97	112	0.66	97.54	19406	21567	1.11	59
Oat+fodder s*arson* - fodder maize + fodder cowpea	20.96	39.81	20.96	39.81	60.77	166	0.99	144.69	21660	39105	1.81	107
Oat + fodder *sarson* - guinea grass + fodder cowpea	19.91	36.69	19.91	36.69	56.60	155	0.92	134.76	23639	32953	1.39	90
Oat+fodder s*arson* - sorghum + fodder cowpea	19.82	31.40	19.82	31.40	51.22	141	0.83	121.95	23328	27891	1.19	76
S.Em±	-	-	0.29	0.51	0.46	-	-	-	-	764	0.01	-
CD (P=0.05)	-	-	0.93	1.48	1.38	-	-	-	-	2281	0.04	

Wheat= Rs.850/q, Maize= Rs.750/q, Green fodder = Rs.150/q

better than guinea grass and sorghum and resulted in higher green fodder equivalent yield in all the cropping systems comprised of fodder maize. There was a marked effect of growing of cowpea as associated crop on total herbage production. During kharif season growing of cowpea with fodder maize, guinea grass and sorghum resulted in 13.03, 9.11 and 11.48 per cent more green fodder equivalent yield than sole stand of these crops. Fodder maize in the systems also has better effect on the yield of succeeding rabi wheat. Fodder maize resulted in 7.2 per cent increase in rabi season green fodder equivalent yield than grain maize, whereas, guinea grass and sorghum decreased the rabi green fodder equivalent yield by 2.5 and 5.5 per cent, respectively over grain maize based cropping system.

Cropping systems comprised of fodder crops during both the season resulted in significantly higher total green fodder equivalent yield than cropping systems having fodder crops in any of the season. Grain based cropping system i.e. wheat – maize, produced minimum green fodder equivalent yield. The grain yield of crops during both the seasons failed to compete with high green biomass yield and better economic returns of fodder crops. The green fodder equivalent yield of oat + fodder sarson – maize cropping system was statistically at par with wheat - maize system, indicating scope for the inclusion of fodder crops during rabi season in place of wheat.

Efficiency analysis

Oat + fodder sarson – fodder maize + fodder cowpea cropping system showed higher production efficiency (166 kg/ha/day) and was comparable with wheat - fodder maize (158 kg/ha/day) and oat + fodder sarson – guinea grass + fodder cowpea (155 kg/ha/day) cropping systems (Table 1). Production efficiency of 109 kg/ha/day was recorded with wheat – maize cropping system, which may be due to low green fodder equivalent yield in this treatment. Production efficiency varied from 109 to 158 kg/ha/day in wheat based cropping systems; whereas, in oat + fodder sarson based cropping systems the production efficiency varied from 112 to 166 kg/ha/day. Though wheat - maize system took longer duration but the production efficiency was lower compared to other systems due to low yield in this system.

Wheat – fodder maize cropping system resulted in monetary efficiency of Rs.109/ha/day and was comparable with oat + fodder sarson – fodder maize + fodder cowpea cropping system (Rs.107/ha/day) because of higher yield under this system (Table 1). Lower monetary efficiency of Rs.59/ha/day in wheat - grain maize and oat + fodder sarson – maize is due to low green fodder equivalent yield in these systems. Other cropping systems recorded monetary efficiency between Rs.75/ha/day to Rs.109/ha/day. Variation in monetary efficiency among different system is either because of variation in yield or prices of economic produce of the crops.

Sustainable yield index (SYI)

The sustainable yield index (SYI) values were determined on the basis of total productivity of entire system for eight years under each treatment (Table 1). Oat + fodder sarson - fodder maize + fodder cowpea crop system was highly stable with sustainable yield index of 0.99 and was followed by wheat – fodder maize (0.93) and oat + fodder sarson - guinea grass + fodder cowpea (0.92) cropping systems. These three cropping systems appeared stable in term of sustainability in the region. Data reflects the proportionality of SYI to the production efficiency in all the crop systems. Wheat - maize most popular cropping system in the region proved least sustainable with sustainable yield index of 0.64, due to its lowest production efficiency compared to other treatments.

Nutrient use productivity

The oat + fodder sarson – fodder maize + fodder cowpea cropping system showed highest nutrient use productivity of 144.69 kg green fodder/kg of nutrient applied followed by oat + fodder sarson – guinea grass + fodder cowpea system which produced 134.76 kg green fodder/kg of nutrient applied (Table 1). In wheat based cropping systems inclusion of fodder maize resulted in better nutrient

use productivity (132.48 kg green fodder/kg of nutrient applied) than guinea grass (124.59 kg green fodder/kg of nutrient applied) and sorghum (110.28 kg green fodder/kg of nutrient applied). In oat + fodder sarson based cropping systems fodder maize + fodder cowpea (144.69 kg green fodder/kg of nutrient applied) maintained its superiority over guinea grass + fodder cowpea (134.76 kg green fodder/kg of nutrient applied) and sorghum + fodder cowpea (121.95 kg green fodder/kg of nutrient applied) cropping systems. The nutrient use productivity under different treatments depends on green fodder equivalent yield in respective treatments as nutrients (NPK) applied was similar in all the treatments.

Soil properties

No significant effect of cropping systems was observed on the soil pH over the years, however, organic matter level in all the cropping systems increased over the initial status (Table 2). The addition of FYM for eight year might have contributed toward the improvement of the organic carbon content of the soil in all the treatments. Wheat - fodder maize and oat + fodder sarson - fodder maize + fodder cowpea cropping systems remained statistically at par with each other and resulted in significantly higher organic matter content of 0.80 per cent and 0.79 per cent, respectively and were followed by oat + fodder sarson – guinea grass + fodder cowpea cropping system (0.75%). An improvement in available soil N, P and K over initial levels has been observed. Continuous addition of recommended NPK and FYM for eight crop cycles might have resulted in the improvement of NPK status of soil in all cropping systems over initial values. After the completion of eight crop cycles higher levels of available N was observed in oat + fodder sarson – fodder maize + fodder cowpea cropping system and was at par with oat + fodder sarson – guinea grass + fodder cowpea cropping system, which may be due to the inclusion of cowpea, a legume crop in the system (Rochester *et al.*, 1998), whereas, better effects of cowpea on soil N buildup in oat + fodder sarson – sorghum + fodder cowpea cropping system might have nullified by sorghum an exhaustive crop in this system. Less duration of fodder maize in all the cropping systems might have contributed towards the nutrient build up in the soil. Guinea grass and sorghum appeared exhaustive crops and causes considerable reduction in soil available NPK compared to other cropping systems.

Economic analysis

The data in table 1 showed that the net returns were significantly higher in wheat – fodder maize (Rs. 39,676) cropping system which were at par with oat + sarson – fodder maize + fodder cowpea (Rs. 39,105) cropping system. Although oat + fodder sarson – fodder maize + fodder cowpea cropping system produced higher fodder equivalent yield but more cost of cultivation of this system brought it second in order in terms of net returns. Minimum net returns were obtained in wheat - maize cropping system. Like net returns, benefit: cost ratio was higher with wheat - fodder maize (2.48) cropping system and was followed by oat + sarson – fodder maize + fodder cowpea (1.81) cropping system. Minimum benefit: cost ratio was observed in oat + fodder sarson - maize (1.11) cropping system, whereas wheat-maize and oat + fodder sarson – sorghum + fodder cowpea cropping system remained at par with each other in terms of B:C ratio (1.19).

The study conclusively indicated that under mid hill conditions of North Western Himalayas oat + fodder sarson - fodder maize + fodder cowpea and wheat – fodder maize with higher production efficiency and monetary returns were sustainable cropping systems. To have round the year fodder supply oat + fodder sarson - fodder maize + fodder cowpea or oat + fodder sarson - guinea grass + fodder cowpea appeared suitable cropping systems. Wheat – fodder maize cropping system and oat + fodder sarson - maize appeared suitable cropping systems to produce fodder during kharif and rabi seasons, respectively.

Table 2. Effect of cropping systems on soil properties after completion of eight crop cycles

Cropping systems	Soil properties				
	pH	Organic matter (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Wheat-maize	5.7	0.71	313.2	13.5	310.8
Wheat-fodder maize	5.8	0.80	323.5	14.6	307.8
Wheat-guinea grass	5.7	0.71	299.0	12.4	310.8
Wheat-sorghum	5.6	0.70	292.5	12.2	311.3
Oat+ fodder *sarson* – maize	5.7	0.71	311.7	13.7	314.9
Oat+fodder s*arson* – fodder maize + fodder cowpea	5.7	0.79	326.7	14.7	310.8
Oat + fodder *sarson* – guinea grass + fodder cowpea	5.8	0.75	321.5	13.9	305.3
Oat+fodder s*arson* – sorghum + fodder cowpea	5.7	0.72	310.5	13.3	304.5
S.Em±	-	0.01	3.1	0.4	1.4
CD (P=0.05)	-	0.04	9.9	0.9	4.3
Initial values	**5.7**	**0.69**	**290.2**	**11.03**	**282.16**

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