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Diversification of maize (*Zea mays* L.)-based cropping system for sustainable productivity under mid hill conditions of Himachal Pradesh

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Abstract

An experiment was conducted during 2001–02 and 2002–03 at CSK Himachal Pradesh Krishi Vishvavidyalaya, Oilseeds Research Station, Kangra to find out location specific maize based cropping sequences for higher productivity and economic viability. During *Kharif* season, maize +ginger +brown sarson (as leafy) intercropping gave highest net returns (Rs. 68,540/ha) whereas maize + cucumber and maize as green cob sown in the month of May gave the highest benefit: cost ratio of 3.55 and 2.67, respectively. The sequences; maize–french bean–garlic and maize +cucumber–peas–sunhemp with total productivity of 53.72 and 39.74 tons/ha, production efficiency of 147.18 and 108.88 kg/ha/day, land utilization efficiency of 166.32 and 120.06 kg/day/ha, net returns (Rs. 2, 37,340 and Rs 1, 77,440/ha) and benefit: cost ratio (2.79 and 2.91) were found the best. The other best sequences for higher net returns and benefit: cost ratio were maize (baby corn) –turnip–onion (green + bulb) –sunhemp (Rs 1,45,700 and 2.24) and maize + ginger +brown sarson–potato–sunhemp (Rs 1,40,540 and 1.85). The sequences are sustainable as legume or green manure is component in all sequences.

Key words: Diversification, maize based crop sequence, productivity.

Introduction

Maize – wheat is the most dominant crop sequence in Himachal Pradesh. The productivity of this existing sequence in small and marginal farmers' field is low (Chaudhary and Singh, 1992). Diversification is the only answer if farmers are to make their farming profitable. Since maize is one of the potential *Kharif* crops of the state, diversification within maize cultivation for higher returns is possible through taking up cultivation of maize as green cob, baby corn or as intercropping depending upon market demand and time advantage in sowing. During *rabi* season wheat can be replaced with other crops like oilseeds and vegetables both under irrigated (Saroch *et al.*2005) and limited water supply conditions. These crops can fetch remunerative prices and higher volume of main produce and byproduct which can be used both by human and animal. For diversification we need to identify type of crops, their varieties and duration which fits well in cropping sequence of area. Keeping this in view, the experiment was taken up to work out location specific maize based cropping sequences for higher productivity and economic viability especially for small and marginal farmers.

Material and Methods

The experiment was conducted during 2001–02 and 2002–03 at Oilseeds Research Station, CSK Himachal Pradesh Krishi Vishvavidyalaya, Kangra. The soil of the experimental field was silty clay loam having pH 6.4, medium in nitrogen (265.5 kg/ha), high in phosphorus (26.5 kg/ha) and low in potash (124.2 kg/ha). The treatments comprised of 12 sequences (Table 1) evaluated in randomized block design with three replications. Keeping the arrival of rains factor into consideration i.e. pre monsoon showers (last week of May) and normal onset of monsoon(mid of June), 5 and 7 numbers of sequences were framed for sowing starting from end of May to mid of June, respectively. Different crops and their varieties used were; Maize green (Early composite), cauliflower mid group (Pussy & Palam Uphar), cauliflower late group (PSB–1), radish (Mino early long white), french bean sole (Contender) intercrop (Laxmi), turnip (PTWG), spinach (Pusa Harit), fenugreek (Kassori methi), garlic (GHC 1), cucumber (Paprola local), peas (Palam Priya), broccoli (Palam Samridhi), YLB (PASB-I), ginger (Local), onion (Patna red) and brown sarson (KBS 3). In maize + ginger+brown sarson the brown sarson was taken in rows falling vacant on the harvest of maize crop as ginger crop last till mid December. The onion crop was planted in high density with half of the onion population was harvested as green vegetable to get high prices at that time and half as mature bulb. The main produce of all crops was converted into maize grain equivalent yield whereas byproduct of only maize green, baby corn and grain maize was converted into maize grain equivalent yield. Pooled analysis of data was done for statistical comparison.

Results and Discussion

Kharif season productivity

Intercropping in maize significantly increased the cropping system productivity over sole maize cultivation (Table 1). Maize + ginger+brown sarson (as leafy vegetable) intercropping gave significantly highest maize equivalent yield (17.42 tons/ha) and net returns (Rs 68,540 /ha). This was followed by maize + cucumber and maize + YLB intercropping system with 12.14 and 10.15 ton /ha yields, and Rs 56,840 and Rs 44,880/ha net returns, respectively. Intercropping in maize has been reported to increase the productivity (Balyan, 1997). Sowing maize in month of May for green cob also gave higher net returns (Rs 40, 000). The highest benefit: cost ratio was obtained from maize + cucumber intercropping (3.55) and maize for green cob sown in month of May (2.67).

Total system productivity

The total productivity from the sequence was significantly highest in maize–french bean – garlic (53.72 tons/ha) with sequence cycle starting from the month of May (Table 2). This was followed by maize + YLB–broccoli–french bean (41.08 tons/ha) June sown, maize (baby corn)–radish–cauliflower–french bean (40.86 tons/ha) May sown and maize + french bean–cauliflower–french bean (40.74 tons/ha) June sown and these were also statistically at par with each other. Maize + ginger –brown sarson–potato– sunhemp and maize + cucumber–peas–sunhemp with sequence productivity of 36.09 and 39.74 tons/ha were also found potential sequences as peas and potato are commercial crops with good returns. These sequences have additional advantage of time gap available after harvest of vegetable crop for green manuring. Replacement of wheat with high volume and high value vegetable crops was responsible for higher production and higher productivity of the sequences. Saroch *et al.* (2005) and Chaudhary *et al.* (2001) also reported higher productivity of sequences when wheat is replaced with vegetables. The sequences were sustainable also as all the sequences were having legumes as a component crop and legumes have been reported to increase the fertility and sustain the productivity (Singh *et al.*, 2002 and Dwivedi *et al.*, 2003). Maize– spinach–sunhemp (11.92 ton/ha) and maize–fenugreek–mash (10.87 tons/ha) gave the lowest yield and this was even lower than the maize – brown sarson (leafy+ seed) sequence (13.02 ton/ha) which is a common practice.

Table 1. *Kharif* season crops yield, maize equivalent yield, and returns

Crop sequence (Start of sowing and duration in days)	*Kharif* season yield (tones/ha)			Maize grain equivalent yield (tones/ha)	Net return (Rs/ha)	Benefit: cost ratio
	Main	Intercrop	Intercrop			
Maize(green)–cauliflower–cauliflower–cowpea (GM) (May, 339)	52,000*	–	–	9.17	40,000	2.67
Maize(green)–cauliflower–radish–sunhemp (GM) (June, 331)	45,000*	–	–	6.06	20625	1.29
Maize(baby corn)-radish–cauliflower–french bean (May, 304)	1.70	–	–	5.35	12100	0.61
Maize(babycorn)–turnip–onion (green+bulb)–sunhemp (GM) (June, 324)	1.80	–	–	5.65	13900	0.70
Maize(grain)–spinach–sunhemp (GM) (May,308)	4.84	–	–	5.17	16040	1.07
Maize(grain)–fenugreek–mash (GM) (May,324)	5.22	–	–	5.64	18820	1.26
Maize(grain)–french bean–garlic (May,323)	5.44	–	–	5.86	20140	1.34
Maize(grain)–brown sarson (leafy+seed)–sunhemp (GM) s(June,319)	5.04	–	–	5.46	17740	1.18
Maize+ginger–brown sarson (leafy) – potato–sunhemp (GM) (June,354)	4.84	4.3	1.8	17.42	68540	1.90
Maize + cucumber–peas–sunhemp (GM) (June,331)	4.64	8.6	–	12.14	56840	3.55
Maize+french bean–cauliflower–french bean (June 308)	4.34	0.2	–	5.01	14040	0.88
Maize +YLB–broccoli–french bean (June,289)	4.98	4.3	–	10.15	44880	2.24
CD (P=0.05)				0.22		

Price per kg or number: Maize grain Rs 6/kg Maize green (May) Rs1/cob; Maize green (June) Rs 0.75/cob; Cauliflower (early) Rs 10.0, Mid Rs 8.0 Late Rs 6.0 Radish Early Rs 3.5 and 4.0; turnip Rs 4.0; Spinach Rs 2.45; Fenugreek Rs 5.0 ;cucumber Rs 5.0; Peas Rs 12.0; Frenchbean Rs 8.0 ;broccoli Rs 16.0; Garlic Rs 12.0; Ginger Rs 15.0 ;Onion green Rs 6.0, bulb Rs 8.0; brown sarson leafy Rs 5.0, seed Rs 14.0 and YLB(Yard long bean) Rs 6.75.

Table 2. Yields of crops in sequence, maize- equivalent yield, production and land use efficiency and returns in sequences

Crop sequence	Yields of crops (tons /ha)				Maize equivalent yield (tones/ha)	Production efficiency kg/ha/day	LUE kg/day/ha	Net returns (Rs./ha)	B:C ratio
	Kharif	*Rabi I*	*Rabi II*	*Rabi II*					
Maize(green)–cauliflower–cauliflower– cowpea (GM) (May)	52,000*	12.0	8.0	–	37.17	101.84	109.65	1,08,000	0.94
Maize(green)–cauliflower–radish– sunhemp (GM) (June)	45,000*	14.0	8.5	–	25.71	70.44	77.67	74,250	0.93
Maize(babycorn)–radish–cauliflower–french bean (May)	1.70	11.5	14.8	6.8	40.86	111.95	134.41	1,35,150	1.23
Maize(babycorn)–turnip–onion– sunhemp (GM) (June) (green+ bulb)	1.80	14.2	12.0+6.0	–	35.12	96.22	108.40	1,45,700	2.24
Maize(grain)–spinach–sunhemp (May)	4.84	16.5	–	–	11.92	32.66	38.70	31,540	0.79
Maize(grain)–fenugreek–mash (GM) (May)	5.22	6.2	–	–	10.87	29.78	33.55	24,820	0.62
Maize(grain)–french bean–Garlic (May)	5.44	7.4	19.0	–	53.72	147.18	166.32	2,37,340	2.79
Maize(grain)–brown sarson–sunhemp (GM) (June) (green+seed)	5.04	2.6+1.8	–	–	13.02	35.67	40.82	48,140	1.61
Maize+ginger–brown sarson – potato–sunhemp (GM) (June) (leafy)	4.84 + 4.3+1.8	22.4	–	–	36.09	98.88	101.95	1,40,540	1.85
Maize + cucumber–peas–sunhemp (GM) (June)	4.64+8.6	13.8	–	–	39.74	108.88	120.06	1,77,440	2.91
Maize+french bean–cauliflower–french bean (June)	4.34+0.2	15.4	11.4	–	40.74	111.62	132.27	1,53,440	1.69
Maize +YLB–broccoli–french bean (June)	4.98+4.3	5.4	12.4	–	41.08	112.55	142.15	1,55,480	1.71
SEm±					0.38				
CD (P=0.05)					0.79				

Production and land use efficiency

The production efficiency followed almost same trend as observed for total production from different sequences. Highest production efficiency (147.18 kg/ha/day) and land use efficiency (166.32 kg/day/ha) was obtained from maize–french bean–garlic sequence followed by maize + YLB–broccoli–french bean (112.55 kg/ha/day and 142.15 kg/day/ha) and maize (baby corn)–radish–cauliflower–french bean (111.95 kg/ha/day and 132.27 kg/day /ha) (Table 2). The sequence maize + cucumber–peas–sunhemp was also found to be a good sequence with production efficiency of 108.88 kg/ha/day and land use efficiency of 120.06 kg/day/ha. These sequences have 213.8–312.6 % higher production efficiency over maize – brown sarson (leafy+ seed) –sunhemp sequence in farmers field which was although occupying the land for 319 days in a year.

Economics

Maize–french bean–garlic gave the highest net returns(Rs 2,37,340/ha) with benefit: cost ratio of 2.79 which can be ascribed to value of produce as french bean was off season and garlic has good market price compared to other vegetables. The sequence maize+ cucumber–peas–sunhemp although has low maize equivalent yield compared to maize + french bean–cauliflower–french bean and maize + YLB–broccoli–french bean sequence but gave higher net returns (Rs 1,77,440/ha) and benefit: cost ratio (2.91) because of high value of peas and cucumber as table crop and low input requirement of these crops. Similarly in maize + ginger–brown sarson–potato–sunhemp and maize (baby corn)–turnip–onion (green+ bulb)–sunhemp the inclusion of onion and potato having high value of produce also resulted in higher benefit: cost ratio of 1.85 and 2.24, respectively. It is also interesting to note that where ever legume was involved in the sequence the benefit: cost ratio remained above 1.5 indicating sustainability of soil and stability for small farmers. The replacement of wheat with vegetables increased the returns compared to oilseeds. Shah *et al.* (1999) also reported lower yield when wheat was replaced with oilseeds in the sequence.

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