Short Communication

Evaluation of different crop sequences for yield, crop duration, land use efficiency and per day food availability

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Abstract

An experiment was conducted during 2018-19 in the mid-hill conditions of Himachal Pradesh at Bhadiarkar experimental farm of Department of Agronomy, College of Agriculture, CSK HPKV, Palampur (H.P.). The experiment comprised of ten treatments (maize-wheat; maize-wheat + gobhi sarson; dhaincha-early cabbage-frenchbean; sunhemp-vegetable pea-frenchbean; maize + soybean-chickpea + linseed; rice-wheat + gram; hybrid sorghum + hybrid bajra-oats + sarson (hybrid); hybrid sorghum + hybrid bajra-ryegrass + berseem; babycorn-broccoli-frenchbean and okra-turnip-tomato) which was laid out in randomized block design with three replications.All the crop sequences have higher food availability in comparison to the rice-wheat + gram and maize-wheat (16.44 and 17.92 kg ha^{-1} day^{-1}).The diversification of the traditional crop sequences not only lead to better utilization of the land resources but also provided higher food availability.

Key words: Crop sequences, diversification, food availability, land use efficiency, maize.

Indian Agriculture is striving to find ways to face challenges due to increasing population, food and fodder needs, natural resource degradation, higher cost of inputs and concerns of climate change. India requires not only increased cereal production but also other commodities like fodder, fibre, oil, pulses which poses a grave challenge to produce more and more from inadequate and degraded land and water resources. As of now the productivity of many field crops has plateaued, and factor productivity is declining year after year. In India, a large number of crops are grown due to diverse and changing Agro-climatic conditions and crop diversification is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops. Crop diversification aims to give a wider choice of a variety of crops to be grown in a given area, to expand and refine production-related activities of various crops and also minimize risk especially under rainfed conditions of Himachal Pradesh, where crop failure may occur due to erratic and insufficient rainfall.

Crop diversification shows lot of promise in alleviating the second generation problems such as raising or lowering of water table, insect-pests and diseases, environmental pollution, decline in farm profit and changing climate, through fulfilling basic needs for cereals, pulses, oilseeds and vegetables and regulating farm incomes, withstanding weather aberrations, controlling price fluctuations, ensuring balanced food supply, conserving natural resources, reducing chemical and fertilizer loads, environmental safety and creating employment generation. At present, among cereal-based cropping systems, rice-wheat and maize-wheat are the continuous cropping systems resulting in reduced soil fertility and predominance of specific weeds (Katyal 2003). Thus, the present systems can be diversified with more productive and profitable crops including oilseeds, pulses, spices as well as fruits and vegetables.Maize is one of the major cereal crops, has wide adaptability under diverse agroclimatic conditions, serving an important driving crop for diversification under all ecologies. In India, it occupies an important place as human food (24%), animal feed (11%), poultry feed (52%) and industrial uses (12%) (Kumar *et al.,* 2013). In the peri-urban interface, the inclusion of high-value crops into the maize-based intercropping or sequential cropping systems proved to be profitable and remunerative (Singh 2006).

The field experiment was carried out during 2018-19 in the mid-hill conditions Himachal Pradesh at Bhadiarkar experimental farm of Department of Agronomy, College of Agriculture, CSK HPKV, Palampur (H.P.) which lies at a latitude of 32°04' N and longitude of 76°35' E with an elevation of 1100 m above mean sea level in North-Western Himalayas. The experiment comprised of ten treatments (maize-wheat; maize-wheat + gobhi sarson; dhaincha-early cabbage-frenchbean; sunhemp-vegetable pea-frenchbean; maize + soybean-chickpea + linseed; rice-wheat + gram; hybrid sorghum + hybrid bajra-oats + sarson (hybrid); hybrid sorghum + hybrid bajra-ryegrass + berseem; babycorn-broccoli-frenchbean and okra-turnip-tomato) was laid out in randomized block design with three replications. The soil of the experimental site was silty clay loam in texture, acidic in reaction with pH 5.3, low in available nitrogen (276 kg ha^{-1}), high in available phosphorus (34.28 kg ha^{-1}) and medium in available potassium (132.45 kg ha^{-1}). All the crops in the sequences were applied with recommended dose of fertilizers as recommended by the State Agriculture University.

Crop Studies

Crop yield

The crops in most of the treatments produced comparatively lower yields corresponding to their reported yields of the region except for maize, wheat, sorghum, bajra and linseed. The yields of the different vegetable crops supplanting maize in *kharif* and wheat in *rabi viz.,* okra, cabbage, vegetable pea, broccoli, turnip, frenchbean and tomato fluctuated from low to very low. The main reason for low yield in case of okra is poor germination and sparse plant population due to very high rainfall before and immediately after the sowing of the crop. Highest total economic yield was obtained from hybrid sorghum + hybrid bajra-oats + sarson (hybrid) followed by hybrid sorghum + hybrid bajra-ryegrass + berseem, okra-turnip-tomato and dhaincha-early cabbage-frenchbean (Table 1).

Sowing of sequential crop was difficult due to very high rainfall. The low yield in *rabi* vegetables was due to the periodic rainfall leading to waterlogging followed by high temperatures which increased the mortality of the seedlings thereby leading to low production.

Land use efficiency and crop duration

The treatment which involved the fodder crops *viz.,* hybrid sorghum + hybrid bajra-oats + sarson (hybrid) appropriated the land for the most comprehensive duration thus lead to highest land utilization (333 days *i.e.* 91.23%). This was closely followed by another fodder crop treatment hybrid sorghum + hybrid bajra-ryegrass + berseem (329 days *i.e.* 90.14%) and okra-turnip-tomato with 329 days duration and 90.14% efficiency (Table 2). Dhaincha-early cabbage-frenchbean had a more fallow period in between which diminished the duration of land cover to 253 days and dropped the land utilization efficiency by 2.73% compared to the maize-wheat sequence which gives us the possibility to further intensify the said system.

Food availability

In general, higher availability of food is expected from the treatments comprising of vegetable crops which is mainly due to the higher production in comparison to the food grain crops. Hybrid sorghum + hybrid bajra-oats + sarson (hybrid) sequence was the highest among all other treatments *per se* okra-turnip-tomato sequence (81.64 kg ha^{-1} day^{-1}) was the highest among the treatments considered for the human consumption (Table 3). This was followed by dhaincha-early cabbage-frenchbean (78.49 kg ha^{-1}) and sunhemp-vegetable pea-frenchbean (64.44 kg ha^{-1} day^{-1}). All the crop sequences have higher food availability in comparison to the rice-wheat + gram and maize-wheat (16.44 and 17.92 kg ha^{-1} day^{-1}) sequences under study.

Table 1. Crop yield under different crop sequences

Treatment	Yield (kg ha^{-1})					
	Kharif	*Kharif* Intercrop	*Rabi*-I	*Rabi*-I Intercrop	*Rabi*-II	Total
T_1	4015	-	2525	-	-	6540
T_2	5429	-	1326	227	-	6982
T_3	11111	-	13131		4407	28649
T_4	12247	-	6692	-	4583	23522
T_5	5069	400	110	1263	-	6842
T_6	3535	-	2399	66	-	6000
T_7	22980	-	35732	-	-	58712
T_8	23232	-	34091	-	-	57323
T_9	6402	-	7449	-	4520	18371
T_{10}	1263	-	17803	-	10732	29798

T_1: Maize -wheat; T_2 : Maize -gobhi sarson + toria;T_3 :Dhaincha-early cabbage -frenchbean;T_4 :Sunhemp-vegetable pea-frenchbean;T_5 :Maize + soybean-chickpea + linseed;T_6:Rice-wheat + gram;T_7:Hybrid sorghum + hybrid bajra -oats + sarson (hybrid);T_8 :Hybrid sorghum + hybrid bajra -ryegrass + berseem;T_9 :Babycorn-broccoli-frenchbean;T_{10}: Okra-turnip-tomato

Table 2. Duration and LUE under different treatments

Treatment	Cropping Sequence	Duration (days)	LUE (%)
T1	Maize-Wheat	263	72.05
T2	Maize-Gobhi sarson + Toria	295	80.82
T3	Dhaincha-Early Cabbage-Frenchbean	253	69.32
T4	Sunhemp-Vegetable Pea-Frenchbean	276	75.62
T5	Maize + Soybean-Chickpea + Linseed	321	87.95
T6	Rice-Wheat + Gram	296	81.10
T7	Hybrid Sorghum + Hybrid Bajra-Oats + Sarson (Hybrid)	333	91.23
T8	Hybrid Sorghum + Hybrid Bajra-Ryegrass + Berseem	329	90.14
T9	Babycorn-Broccoli-Frenchbean	285	78.08
T10	Okra-Turnip-Tomato	329	90.14

Table 3. Food availability under different crop sequences

Treatment	Cropping Sequence	Total yield (kg ha^{-1})	Food availability (kg ha^{-1} day^{-1})
T1	Maize-Wheat	6540	17.92
T2	Maize-Gobhi sarson + Toria	6982	19.13
T3	Dhaincha-Early Cabbage-Frenchbean	28649	78.49
T4	Sunhemp-Vegetable Pea-Frenchbean	23522	64.44
T5	Maize + Soybean-Chickpea + Linseed	6842	18.75
T6	Rice-Wheat + Gram	6000	16.44
T7	Hybrid Sorghum + Hybrid Bajra-Oats + Sarson (Hybrid)	58712	160.86
T8	Hybrid Sorghum + Hybrid Bajra-Ryegrass + Berseem	57323	157.05
T9	Babycorn-Broccoli-Frenchbean	18371	50.33
T10	Okra-Turnip-Tomato	29798	81.64

Conclusion

The diversification of the traditional crop sequences involving cereals, pulses and oilseeds not only lead to higher utilization of the land resources but also provided higher food availability. The farmers who are more or less dependent on livestock for their livelihood can opt for either hybrid sorghum + hybrid bajra-oats + sarson (hybrid) or hybrid sorghum + hybrid bajra-ryegrass + berseem for more fodder yields. The farmers whose livelihood depends exclusively on agricultural farming could go for the okra-turnip-tomato crop sequence as it would provide higher crop yields.

Conflict of interest: There is no conflict of interest among the authors.

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