Himachal Journal of Agricultural Research 50(2): 279-283 (2024)

Short communication

Effect of diverse cropping systems on crop indices and resource use efficiency under natural farming

Mohit Naik*, Maan Chand Rana, Gurbhan Das Sharma, Tarun Sharma and Bharat Bhushan Rana
Department of Agronomy, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, H.P. - 176 062

*Corresponding e-mail id: mohitnaik26@gmail.com
Manuscript received: 18.10.2024; Accepted: 26.10.2024

Abstract

A field experiment was conducted to study the effect of diverse cropping systems on crop indices and resource use efficiency under natural farming during 2020-21 to 2021-22 with nine treatments (C_1 -Maize - wheat, C_2-Black gram - wheat + gram, C_3-Soybean - wheat + lentil, C_4-Cowpea - wheat + mustard, C_5-Okra - wheat + pea, C_6-Maize + black gram - gram, C_7-Maize + soybean - lentil, C_8-Maize + cowpea –mustard and C_9-Maize + okra - pea), replicated thrice in Randomized Block Design. The land equivalent ratio among the intercropping system was higher in first year but slightly drops by 0.92 % (C_2) in *rabi* and 8.28 % (C_7) in *kharif* 2021. C_2 recorded significantly higher cultivated land utilization index, followed by C_6. Both C_6 and C_2 recorded significantly higher land use efficiency while enhanced system productivity was observed in C_5 followed by C_9 and that of vice-versa for enhanced productivity efficiency.

Keywords: Crop indices, cropping system, efficiency, natural farming, productivity, resource use

Agriculture acts as the cornerstone of global food security; has come under pressure due to exploitation of natural resources, population explosion and environmental degradation (Godfray *et al*. 2010). After Organic Farming, recently Natural farming introduced as an eco-friendly farming approach; with no use of synthetic chemical pesticide, promotes soil health, biodiversity and overall ecosystem function (Altieri & Nicholls 2020). Natural farming not only aims to remediation environmental impact but also improves the efficiency in resource use and yield for sustained agricultural productivity. To be considered sustainable, agriculture must show increased efficiency in both resource use and yield efficiency (Pretty *et al*. 2018).

Addition of the diverse crops including legumes and vegetable crops in cropping system as part of natural farming practices is one way to enhance the productivity and sustainability. Intercropping, crop rotation, and mixed cropping—in contrast to monocropping—offer several advantages, such as improving soil fertility, lowering resource use, and reducing pest and disease incidence (Sharma *et al*. 2011). Overall productivity can increase by growing multiple crops on the same plot of land while promoting better resource utilization and enhancing the resilience of farming systems (Lichtfouse 2009). Keeping this in view, the present investigation was planned to study the effect of diverse cropping systems on crop indices and resource use efficiency under natural farming.

A two-year field experiment was carried out during *rabi* 2020-21 to *kharif* 2022 at the research farm, department of Agronomy, CSKHPKV, Palampur, Kangra, Himachal Pradesh. The experiment was carried out in randomised block design with three replication and nine cropping system. The soil type was silty-clay loam having low amounts of potassium and nitrogen, moderate level of phosphorus, and an acidic content. The treatments comprised of C_1 -Maize - wheat, C_2-Black gram - wheat + gram, C_3-Soybean - wheat + lentil, C_4-Cowpea - wheat + sarson, C_5-Okra - wheat + pea, C_6-Maize + black gram - gram, C_7-Maize + soybean - lentil, C_8-Maize + cowpea - sarson and C_9-Maize + okra – pea.The natural farming inputs includes *beejamrit* (used for seed treatment @ 1 litre/10 kg seed), *jeevamrit* (5 drenching application at 21 days interval; total used 450 litres), *ghanjeevamrit*

(soil applied during sowing @ 500 kg ha^{-1}) and mulching (applied after germination @ 10000 kg ha^{-1}). In the *rabi* season the crops were sown in replacement series in intercropping system, while in *kharif* crops were sown in additive series. The data was analysed using R-software for Land Equivalent Ratio (LER), Cultivated Land Utilization Index (CLUI), Land use efficiency (%), System productivity (kg ha^{-1} day^{-1}) and Productivity efficiency (kg WEY ha^{-1} day^{-1}).

All intercropping treatments achieved LER values greater than 1.0 in both years of experimentation (Table 1). In the *rabi* 2020-21, the largest LER (1.09) was obtained in the combination of wheat with gram, followed by wheat with lentil which was at par in the combination wheat with sarson (1.05). In the subsequent season of *kharif* 2021, the highest LER (1.45) was obtained in the maize with soybean, followed by maize with cowpea (1.42). Whereas, in the *rabi* 2021-22, the largest LER (1.08) was obtained in the combination of wheat with gram, followed by wheat with lentil which was at par in the combination wheat with sarson (1.07). During *kharif* 2022, the largest LER (1.37) was obtained in the maize with cowpea, followed by maize with soybean which was at par in the combination of maize with okra (1.33). Singh *et al*. (2017) found that intercropping pigeon pea with sorghum achieved an LER of 1.35, indicating a 35% increase in land use efficiency compared to sole cropping. The increase in yield attributed to reduction in LER in the next year. A greater resource use and resource complementarily in intercrops attributed to higher LER compared to crops grown in sole. Similarly, Patra *et al*. (2018) reported LER values of 1.40 in intercropping system involving groundnut and maize. Sharma *et al*. (2020) on intercropping of chickpea and wheat in the semi-arid regions of India showed LER values ranging from 1.2 to 1.4.

The Cultivated land utilization index (CLUI) indicates the efficient utilization of land being done properly or not. The CLUI for different cropping system during the year 2020-21 and 2021-22 (Table 2). Among the cropping systems, the C_2 (black gram - wheat + gram) system recorded significantly higher CLUI at 0.57 and 0.58, followed by the C_6 (maize + black gram – gram) system at 0.52 and 0.53 during 2020-21 and 2021-22, respectively. While the lowest CLUI recorded in C_9 (maize + okra – pea) system at 0.38 and 0.39, respectively. The addition of short duration crops like black gram attributed to higher CLUI compared to other (Tetarwar *et al*. 2023). Wheat-legume system has shown to maximize land utilization efficiency while maize/okra rotation systems may have shorter growing seasons leading to decreased land

Table 1. Effect of cropping systems on land equivalent ratioduring crop seasons 2020-21 and 2021-22

Cropping system	2020-21		2021-22	
	Rabi	***Kharif***	***Rabi***	***Kharif***
C_1 Maize – wheat	-	-	-	-
C_2 Black gram – wheat + gram	1.09	-	1.08	-
C_3 Soybean – wheat + lentil	1.05	-	1.07	-
C_4 Cowpea – wheat + sarson	1.05	-	1.07	-
C_5 Okra – wheat + pea	1.04	-	1.02	-
C_6 Maize + black gram – gram	-	1.38	-	1.24
C_7 Maize + soybean – lentil	-	1.45	-	1.33
C_8 Maize + cowpea – sarson	-	1.42	-	1.37
C_9 Maize + okra – pea	-	1.40	-	1.33

utilization efficiency (Kumar *et al*. 2022).

Land use efficiency (LUE) observed during the experimentation period presented in Table 2. Among the diverse cropping system, significantly higher LUE observed in the C_6 (maize + black gram - gram) system 87.03 % and 88.22 %, at par with C_2 (black gram - wheat + gram) system at 87.03 % and 87.85 % in 2020-21 and 2021-22, respectively, followed by C_1, C_3, C_5 and C_7 system in both years. Whereas, the lowest LUE observed in the C_9 (maize + okra - pea) system at 75.16 % and 75.89 % in 2020-21 and 2021-22, respectively. The differences in crop duration of crops attributed to variation in LU Eduring both the year. Higher LUE in intercropped systems results from better resource utilization and complementary crop growth patterns. Intercropping legumes with cereals can lead to increase in LUE by 20-30 %, additionally improve soils nutrient status (Fischer *et al*. 2018). Also, intercropping and mixed cropping system might result in higher yield per unit area, improving land use (Adetunji *et al*. 2017).

The data on system productivity observed during the experimentation period presented in the Table 3. Among the system, significantly higher system

Table 2. Effect of cropping systems on cultivated land utilization index ratio and land use efficiency during crop seasons 2020-21 and 2021-22

Cropping system	Cultivated Land Utilization Index		Land use efficiency (%)	
	2020-21	2021-22	2020-21	2021-22
C_1 Maize - wheat	0.46	0.46	82.56	83.38
C_2 Black gram - wheat + gram	0.57	0.58	87.03	87.85
C_3 Soybean - wheat + lentil	0.50	0.50	82.65	83.20
C_4 Cowpea - wheat + sarson	0.49	0.49	81.28	82.01
C_5 Okra - wheat + pea	0.47	0.48	82.56	83.84
C_6 Maize + black gram - gram	0.52	0.53	87.12	88.22
C_7 Maize + soybean - lentil	0.47	0.48	82.28	83.29
C_8 Maize + cowpea - sarson	0.44	0.44	78.17	79.09
C_9 Maize + okra - pea	0.38	0.39	75.16	75.89
SEm (±)	NS	NS	0.29	0.54
LSD (P=0.05)	NS	NS	0.86	1.62

Table 3. Effect of cropping systems on system productivity and productivity efficiency during crop seasons 2020-21 and 2021-22

Cropping system	System productivity (kg ha^{-1} day^{-1})		Productivity efficiency (kg wheat equivalent yield ha^{-1} day^{-1})	
	2020-21	2021-22	2020-21	2021-22
C_1 Maize - wheat	12.72	13.58	15.41	16.30
C_2 Black gram - wheat + gram	11.12	11.75	12.77	13.37
C_3 Soybean - wheat + lentil	15.17	15.76	18.35	18.95
C_4 Cowpea - wheat + sarson	11.38	11.65	14.00	14.21
C_5 Okra - wheat + pea	35.74	36.35	43.29	43.36
C_6 Maize + black gram - gram	14.51	14.66	16.65	16.61
C_7 Maize + soybean - lentil	16.35	16.89	19.87	20.28
C_8 Maize + cowpea - sarson	13.63	14.07	17.43	17.80
C_9 Maize + okra - pea	35.39	35.73	47.09	47.09
SEm (±)	0.28	0.29	0.34	0.38

productivity of 35.74 kg ha^{-1} day^{-1} and 36.35 kg ha^{-1} day^{-1} observed in the C_5 (okra – wheat + pea), followed by C_9 (maize + okra – pea) system at 35.39 kg ha^{-1} day^{-1} and 35.73 kg ha^{-1} day^{-1} during 2020-21 and 2021-22, respectively. Whereas, the lowest system productivity observed in the C_2 (black gram – wheat + gram) and C_4 (cowpea – wheat + sarson) system during both the years. The high yield potential and extended growing periods attributed to improved biomass accumulation in vegetables like okra and pea resulted in higher productivity in the C_5 and C_9 system. Compared to vegetables, lower yield potential and shorter growth cycles of legumes attributed to lower productivity in C_2 and C_4 system. Addition of the vegetables like okra and pea in intercropping system resulted in enhanced biomass production, resources use efficiency increased overall system productivity and also provides economic benefits. (Bhattacharyya *et al*. 2020; Sharma *et al*. 2021; Thakur *et al*. 2022).

Significantly higher productivity efficiency of 47.09 kg WEY ha^{-1} day^{-1} observed in C_9 (maize + okra – pea) system both the year, followed by C_5 (okra – wheat + pea)system at 43.29 kg WEY ha^{-1} $day^{-1}$and 43.36 kg WEY ha^{-1} day^{-1}during 2020-21 and 2021-22, respectively (Table 3). Whereas, the lowest productivity efficiency observed in the C_2 (black gram – wheat + gram) and C_4 (cowpea – wheat + sarson) system during both the years. The productivity efficiency observed in the C_9 and C_5 system, which include vegetables *viz*. okra and pea, resulted in higher okra fruit and pea pods. In contrast, lower productivity in black gram due to its short growth duration and lower yield potential compared other system, which attributed to reduced productivity efficiency in the C_2. Additionally, the better nutrient uptake and diverse growth cycles vegetable-based systems contribute to their higher productivity efficiency. Mishra *et al*. (2019) reported that while cereals intercrop with okra resulted in higher fruit yield and better nutrient uptake attributed to higher productivity efficiency.

Conclusion

As legumes are known for their N fixing nature results in improved fertility, while the vegetables like okra and pea resulted in higher economical yield. The results reveals that the system includes intercrops continuously surpass the sole cropping in respect of land equivalent ratio, cultivated land utilization index, land use efficiency, system productivity, and productivity efficiency. Cropping systems with legumes *viz*. C_2 (black gram - wheat + gram) and C_8 (maize + cowpea – sarson) resulted in higher LER values and land use efficiency, despite that maize-based intercropping systems yielded higher productivity. Under natural farming overall enhanced productivity were observed under the systems, which includes vegetable like okra and pea.

Conflict of interest: Authors declare no competing interest.

References

Adetunji MO, Olayinka A and Olaniyan AB 2017. Land use efficiency in intercropping systems. Journal of Agronomy and Crop Science **203 (6):** 528-537.

Altieri MA and Nicholls CI 2020. Agroecology and the emergence of a post COVID-19 agriculture. Agriculture and Human Values **37 (3):** 525-526.

Bhattacharyya R, Chakraborty D and Mukherjee A 2020. Productivity benefits of intercropping systems. Field Crops Research **254:** 107821.

Fischer AJ, Ramírez HV and Silva AP 2018. Enhancing land use efficiency with legumes in cropping systems. Agricultural Systems **163:** 53-61.

Godfray HCJ, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JF, Pretty J, Robinson, S, Thomas SM and Toulmin C 2010. Food security: The challenge of feeding 9 billion people. Science, **327 (5967):** 812-818.

Kumar R, Manuja S, Sharma, RP, Sharma, GD and Verma S 2022. Evaluation of different components of natural farming in black gram (*Vigna mungo* L.) under mid hill conditions of Himachal Pradesh. Himachal Journal of Agricultural Research **47 (2):** 175-179.

Lichtfouse E 2009. Organic farming, pest control and remediation of soil pollutants. Springer Science & Business Media. https://doi.org/10.1007/978-1-4020-9654-9

Mishra B, Sahu GS, Tripathy P, Mohanty S and Pradhan B 2019. Effect of integrated nutrient management (INM) on growth, yield, nutrient uptake and soil fertility in okra (*Abelmoschus esculentus* (L.) Moench) cv. Pusa A-4. Journal of Pharmacognosy and Phytochemistry **8 (5):** 1011-1014.

Patra AK, Ghosh BN, Srivastava AK and Singh R 2018. Efficiency of maize-groundnut intercropping system

under different nitrogen levels. Agricultural Research **7 (1):** 89-95.

Pretty J, Benton TG, Bharucha ZP, Dicks LV, Flora CB, Godfray HCJ, Goulson D, Hartley S, Lampkin N, Morris C, Pierzynski G, Pywell R, Reganold J, Rockström J, Smith P, Thorne P and Wratten S 2018. Global assessment of agricultural system redesign for sustainable intensification. Nature Sustainability **1 (8):** 441-446.

Sharma A, Sharma JJ, Rana MC and Sood S 2011. Evaluation of Phaseolus vulgaris as intercrop with vegetables for enhancing productivity system and profitability under high hill dry temperate conditions of north-western Himalayas. The Indian Journal of Agricultural Sciences **76 (1):** 29-32.

Sharma T, Singh J and Kaur N 2021. Effect of organic sources of nutrients on growth and growth indices of cowpea (*Vigna unguiculata*) under mid hill conditions of Himachal Pradesh. Himachal Journal of Agricultural Research **46 (2):** 201-204.

Sharma V, Kumar A and Singh M 2020. Land equivalent ratio and yield advantage in chickpea-wheat intercropping system. Journal of Plant Nutrition **43 (3):** 456-465.

Singh A, Prajapati RK and Sharma BK 2017. Performance of pigeon pea and sorghum intercropping system under rainfed conditions. Indian Journal of Agronomy **62 (3):** 315-318.

Tetarwar JP, Ram B, Bijarnia A and Singh P 2023.Performance of diversified cropping sequences for productivity, profitability and land use efficiency under South-east-ern Rajasthan, India. Indian Journal of Agronomy **68 (1):** 77–82.

Thakur A, Gangmei TP, Kumar A and Manuja S 2022. Effect of irrigation levels on growth and yield of different Brassica species under natural and conventional farming. Himachal Journal of Agricultural Research **48 (2):** 280-284.