October 31, 2023

https://ijoabs.com/
DOI: 10.5281/zenodo.11408269

Organic Basmati Rice Based Cropping Systems for Enhancing System Productivity under Sub-Tropical Agro Climatic Conditions of Jammu and Kashmir

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Received Date: 24-June-2023 Accepted Date: 29-July-2023 Published Date: 30-Oct-2023

Abstract:
Field experiments were conducted during the Kharif and Rabi seasons of 2017-18, 2018-19 and 2019-20 at the Organic Farming Research Centre, SKUAST-Jammu to find out the most efficient organic basmati rice based cropping systems for enhancing system productivity under sub-tropical agro climatic conditions of Jammu and Kashmir. The experiment comprised of different basmati rice based cropping systems viz. Basmati rice - Wheat - Moong, Basmati rice - Wheat - Dhaincha, Basmati rice – Mustard - Moong, Basmati rice - Mustard - Mash, Basmati rice - Berseem - Mash, Basmati rice - Broccoli - Moong, Basmati rice – Berseem - Moong, Basmati rice - Lentil – French bean, Basmati rice – Methi - Dhaincha and Basmati rice - Pea- Dhaincha under organic conditions. The highest plant height, number of tillers, leaf area, LCC, 1000-grain weight, grain yield, straw yield, biological yield and harvest index were recorded in Basmati rice – Berseem - Moong Cropping system. Moreover, this system also gave highest rice equivalent yield, net returns and B: C ratio (3.49 and 3.45). Therefore, Basmati rice – Berseem - Moong Cropping system was found to be the most suited cropping system for enhancing system productivity under sub-tropical agro climatic conditions of Jammu and Kashmir.

Keywords: *Organic, basmati rice, cropping systems, productivity, equivalent yield.*

INTRODUCTION

The cropping system is defined as the order in which the crops grown in a given area within a year. The agriculture forms and cropping systems found all over the world are the results of variations in local climate, soil, economics and social structure. It's not only illustrate the current land use but also reflect how the land use pattern have changed over the period of time, particularly in irrigated and rainfed ecosystems (Chitale *et al.*, 2016). Rice-based cropping system is a major cropping system practiced in India, which can be described as a mix of farming practices, and consists of rice as the main crop, followed by cultivation of other crops involving cereals, pulses, oilseeds, cotton, sugarcane, green manures, vegetables, etc. Rice based cropping systems may include lowland and upland crops. In rice growing regions, several cropping systems

are in practice depending on the agro-ecological conditions, market and domestic needs and facilities available with the farmers (Deep *et al.,* 2018). In Jammu and Kashmir, the predominant cropping systems are maize-wheat and rice-wheat in rainfed and irrigated areas, respectively in Jammu region and rice-mustard and rice-oat (fodder) in Kashmir valley.

Rice cultivable area in India is 43.78 million hectares contributing 118.43 million tonnes of food grain production with an average productivity of 27.05 quintals per hectare (Anonymous, 2020 a). Geographical indicator (GI) for Basmati rice increased more area under Basmati rice cultivation in the plains of North-Western Indian Himalayan region. Basmati, the aromatic rice praised for its unique quality, anature's gift to Indian sub- continent. It is cultivated on the foot hills of the Himalayas in the North-Western parts of Indian subcontinent comprising the states of Haryana, Punjab, Uttaranchal, Western Uttar Pradesh, Jammu & Kashmir, Himachal Pradesh and Delhi. In Jammu & Kashmir it plays an important role in the livelihood of people. Basmati rice in sub-tropical zone of Jammu region is grown on an area of 54.3 thousand hectares. Further, the major variety grown in Jammu and Kashmir is Basmati 370 which accounts for 69 per cent of the share of basmati acreage in Jammu and Kashmir (Anonymous, 2019).

The present rate of rice production growth (0.36%) is far below the population growth rate of 1.63% (Anonymous, 2020 b). Therefore, there is a need to increase the rice system productivity to meet growing food needs of population of the country. The cropping system is location-specific, so it is important to clearly understand the local environment before developing an alternate cropping system for a given area. When recommending an alternate cropping system for a location, it is typically assumed that the physical resources are not being completely utilised and that this void can be filled by intensifying cropping intensity. Therefore, the present study was done to evaluate different Organic Basmati rice (*Oryza sativa* L.) based cropping systems for system productivity under sub-tropical agro climatic conditions of Jammu and Kashmir.

MATERIALS AND METHODS

Study was conducted during *Kharif and Rabi* seasons of2017-18, 2018-19 and 2019-2020 at the Organic Farming Research Centre, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Main Campus Chatha, located at $32^0 40'$ North latitude and $74^0 58'$ East longitude with an altitude of 332 meters above mean sea level in the Shiwalik foothills of North-Western Himalayas. Jammu is located in sub-tropical zone bestowed with hot and dry early summers followed by hot and humid monsoon season and cold winters. The mean annual rainfall of the experimental site is 1198.2 mm of which 70-75 percent rainfall is received from June to September, whereas remaining 25-30 percent of rains are received in few showers during winter as a result of Western disturbances from January to March. The soil of the experimental field was sandy clay loam in texture with pH 7.5, medium in organic carbon, available phosphorus and potassium but low in available nitrogen. Temperature at Chatha ranges from 30-41°C during different growth stages of rice beginning from nursery sowing from mid-May to maturity stages in end October.

Treatments consisted of different Basmati rice based cropping systems*viz.* Basmati rice - Wheat – Moong, Basmati rice - Wheat –Dhaincha, Basmati rice - Mustard – Moong, Basmati rice - Mustard – Mash, Basmati rice – Berseem - Mash, Basmati rice - Broccoli – Moong, Basmati rice - Berseem - Moong, Basmati rice - Lentil – French bean, Basmati rice – Methi - Dhaincha and Basmati rice - Pea- Dhaincha under organic conditions. The experiment was laid out in randomized complete block design and the treatments were replicated thrice. Recommended package of practices were followed for basmati rice production. Five plants were randomly chosen and labelled in each plot for the growth studies conducted during the rice crop growth period, with the exception of the measurements for leaf area. Observations on plant height, number of tillers, leaf area, LCC, 1000- grain weight, grain yield, straw yield, biological yield and harvest index were recorded. Plant height was measured from the ground level to the tip of the top most fully opened leaf and expressed in cm. For determining grain yield, all the plants from net plot area were harvested separately, threshed manually and the grain yield for each treatment was expressed in q/ha at appropriate moisture. Rice equivalent yield (REY) was calculated to compare system performance by converting the yield of non-rice crops into equivalent rice yield on a price basis according to Lal *et al*. (2017) and described as:

REY = $Y_x(P_x/P_r)$, where Y_x is the yield of non-rice crops (q ha^{-1}), P_x is the price of non-rice crops (₹ q^{-1}), and P_r is the price of rice (₹ q^{-1}). Prices of individual inputs and outputs were assumed to be stable during the experimental period.

The collected data on various parameters were analyzed statistically as per the method suggested by Gomez and Gomez (1984) and the results are analysed at five percent critical difference level.

RESULTS

Growth parameters: During three years of study, the growth parameters of Basmati rice varied significantly among different Basmati rice based cropping systems (Table 1). Among different Basmati rice based cropping systems, Basmati rice - Berseem – Moong cropping system recorded significantly higher plant height, number of tillers and leaf area to the tune of 118.54 cm, 9.66 and 58.82, respectively, followed by Basmati rice – Berseem – Mash cropping system to the tune of 114.88 cm (plant height), 9.33 (number of tillers) and 55.90 (leaf area). Whereas Basmati rice - Berseem – Moong cropping system recorded significantly higher values of LCC and 1000- grain weight i.e. 4.52 and 24.10 g, respectively, which was found to be statistically at par with the Basmati rice – Berseem – Mash cropping system (4.24 and 23.74 g for LCC and 1000-grain weight , respectively).

Yield components: Yield of Basmati rice varied significantly among different Basmati rice based cropping systems. It is revealed from Table 2 that among different Basmati rice based cropping systems Basmati rice - Berseem – Moong cropping system recorded significantly highest grain yield and harvest index to the tune of 33.33 q/ha and 29.46 percent, respectively which was found to be statistically at par with the Basmati rice – Berseem – Mash cropping system (32.15 q/ha and 28.95 % for grain yield and harvest index, respectively). Whereas Basmati rice - Berseem – Moong cropping system recorded numerically higher value of straw yield and biological yield to the tune of 79.80 and 113.13 q/ha, respectively in comparison to Basmati rice – Berseem – Mash cropping system to the tune of 78.90 and 111.05 q/ha, respectively.

System productivity: Basmati rice equivalent yield (REY)of various cropping systems differed significantly (Table 2). Maximum basmati rice grain equivalent yield (77.70 q/ha) were recorded in the Basmati rice - Berseem – Moong cropping system which was significantly higher than that of the other systems. It was followed by the Basmati rice – Berseem – Mash cropping system (74.39 q/ha) and Basmati rice - Broccoli-Moong cropping system (52.29 q/ha).

Economics: Basmati rice - Berseem – Moong cropping system gave maximum gross returns and net returns of ₹ 282435 ha^{-1} and ₹ 201596 ha^{--1}, respectively over other treatments (Table 3). The second highest gross returns and net returns of ₹267355 ha^{-1} and ₹189907 ha^{-1}, respectively were recorded under Basmati rice – Berseem – Mash cropping system. The maximum net profit of 249 % and 245 % were recorded Basmati rice - Berseem – Moong and Basmati rice - Berseem - Mash cropping system. The highest benefit: cost (B: C) ratio were achieved with Basmati rice - Berseem – Moong and Basmati rice - Berseem - Mash cropping system (Fig. 1).

DISCUSSION

Rice-based cropping system can be described as mix of farming practices that comprises of rice as the major crop followed by subsequent cultivation of other crops. Intercropping of rice and other compatible crops is also widely practised in many regions. Rice-based cropping system is a major cropping system practised in India, which include the rotation of crops involving cereals, pulses, oilseeds, cotton, sugarcane, green manures, vegetables, etc. Various rice-based cropping systems have been reported from different parts of India ranging from rice-rice-rice to rice followed by different cereals, pulses, oilseeds, vegetables and fibre crops (Deep *et al*., 2018).The increase in the growth parameters of Basmati rice - Berseem – Moong cropping system might be due to the addition of Berseem and moong crops in the sequence as legume crops add Nitrogen in the soil by fixing atmospheric N and enhance the content of available Nitrogen in the soil, which can be utilized by the successive rice crop for its profuse vegetative growth. These results are in close conformity with the findings of Porpavai *et al.* (2011). According to Nanda *et al*. (2010), the basmati based cropping systems (basmati rice-chickpea + coriander and/or basmati rice-vegetable pea + coriander) improved the growth and yield of basmati rice due to higher nitrogen contribution from preceding crop. The increased yield observed in the above cropping systems might be due to inclusion of legume crop which

increased the organic carbon content and available NPK in the system (Kachroo *et al.,* 2014) which led to increased uptake of nutrients from the soil in the successive rice crop. Similar results were reported by Porpavai *et al.* (2011), pointing out the superiority of leguminous crops in increasing the yield of the succeeding rice crop.

Lal *et al*. (2017) observed maximum REY in systems involving green gram and black gram sequences. This might be attributed to the inclusion of legume crop in the *Rabi* and summer seasons in the sequences which lead to increased use of nutrients resulting in higher productivity of the system in terms of REY. Similar findings were also observed by Singh *et al.* (2013). Higher yield of Berseem crop in the system also contributed to higher rice equivalent yield (Dubey *et al*., 2014).

Basmati rice - Berseem – Moong cropping system exhibited higher maximum gross returns, net returns and B: C ratio mainly because inclusion of legume crops intensified the system to add yield and consequently resulted in significantly higher REY. This system and did not need much of land preparation, irrigation, and fertilizer and have lower cost of cultivation than cereals which led to higher net returns and B: C ratio of the system. These results supported the findings of Lal *et al.* (2017) and Banjara *et al*. (2022).

Conclusion: From the summarized results of the present investigation it may be concluded that Basmati rice - Berseem - Moong is the most suitable cropping sequence which gave highest system productivity under sub-tropical agro climatic conditions of Jammu and Kashmir as this cropping system recorded highest grain yield, rice equivalent yield, net returns and B: C ratio.

Conflict of Interest: The Authors declare that there is no conflict of interest

Authors' Contribution Statements: Narinder Panotra conceived the idea and executed the field research with laboratory analyses.

Acknowledgement:

Authors acknowledge the funds provided by Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir

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Table 1: Growth analysis of organic basmati rice crop

S. No.	Treatment	Plant height(cm)	No. of tillers	LCC	Leaf Area Index (cm^2)	1000-Grain weight(g)
1	Basmati rice - Wheat - Moong	92.84	6.66	3.67	40.88	19.46
2	Basmati rice - Wheat - Dhaincha	94.14	7.33	3.56	43.98	20.14
3	Basmati rice - Mustard - Moong	104.79	7.66	3.42	42.68	20.17
4	Basmati rice - Mustard - Mash	88.62	6.33	2.66	39.34	19.98
5	Basmati rice - Berseem - Mash	114.88	9.33	4.24	55.90	23.74
6	Basmati rice - Broccoli- Moong	95.20	7.66	3.62	44.92	20.82
7	Basmati rice - Berseem - Moong	118.54	9.66	4.52	58.82	24.10
8	Basmati rice - Lentil - Frenchbean	105.16	7.66	3.60	42.22	19.90
9	Basmati rice - Methi - Dhaincha	90.22	6.33	3.10	37.36	18.78
10	Basmati rice - Pea - Dhaincha	106.11	8.33	3.92	44.94	20.96
SEm ±		0.13	0.01	0.02	0.10	0.03
CD (P=0.05)		2.60	0.31	0.43	1.87	0.64

Table 2: Organic basmati rice grain yield, straw yield, biological yield, harvest index and rice equivalent yield of the system

S. No	Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest Index (%)	Basmati rice equivalent yield of system (q/ha)
1	Basmati rice - Wheat - Moong	25.05	74.34	99.39	25.20	43.16
2	Basmati rice - Wheat -Dhaincha	26.52	75.60	102.12	25.97	41.95
3	Basmati rice - Mustard - Moong	26.18	75.30	101.48	25.80	43.20
4	Basmati rice - Mustard - Mash	22.92	70.20	93.12	24.61	32.31
5	Basmati rice - Berseem - Mash	32.15	78.90	111.05	28.95	74.39
6	Basmati rice - Broccoli- Moong	26.53	76.00	102.53	25.88	52.29
7	Basmati rice - Berseem - Moong	33.33	79.80	113.13	29.46	77.70
8	Basmati rice - Lentil - Frenchbean	21.13	69.20	90.33	23.39	35.89
9	Basmati rice - Methi - Dhaincha	24.93	74.10	99.03	25.17	44.83
10	Basmati rice - Pea - Dhaincha	26.97	76.20	103.17	26.14	44.47
SEm ±		0.10	0.01	0.03	0.14	0.12
CD (P=0.05)		1.68	0.22	0.65	2.79	2.45

Table 3: Effect of different cropping systems on gross returns, net returns and net profit of organic basmati rice crop.

S. No	Treatment	Gross return (₹/ha)	Net return (₹/ha)	Net Profit (%)
1	Basmati rice - Wheat - Moong	151055	83476	124
2	Basmati rice - Wheat -Dhaincha	146820	91237	164
3	Basmati rice - Mustard - Moong	151210	80967	115
4	Basmati rice - Mustard - Mash	148089	76237	106
5	Basmati rice - Berseem - Mash	267355	189907	245
6	Basmati rice - Broccoli- Moong	218017	126460	138
7	Basmati rice - Berseem - Moong	282435	201596	249
8	Basmati rice - Lentil - Frenchbean	125600	57612	85
9	Basmati rice - Methi - Dhaincha	136919	67001	96
10	Basmati rice - Pea - Dhaincha	145656	77613	114

Fig. 1. Effect of different cropping systems on B: C ratio of organic basmati rice crop