

# Mitigating Food Security Options through Climate Resilient Mustard-maize Based Intercropping Sequences for North-western –Himalayas

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**Abstract** Field experiments were conducted at Dry Land Research Sub-station of Sher-e Kashmir University of Agricultural Sciences and Technology, Jammu during *rabi* (winter) (winter) season of 2008-09 to *kharif* (monsoon)(monsoon) season of 2010 on the same site and layout. The experimental field was well drained upland with bulk density of 1.46 Mg/m<sup>3</sup>. The soil of the experimental site was sandy loam with low in organic carbon (0.42%), available nitrogen (174.2 kg/ha) and medium in available phosphorus (16.5 kg/ha), potassium (124.0 kg/ha) and sulphur (20.4 kg/ha). The study was conducted with the objective to identify the most suitable and promising mustard-maize intercropping sequence in changing climate scenario under *kandi* areas of Jammu region. The two years experimental findings revealed that the system productivity (47.0 and 49.1 kg/ha/day), production efficiency (59.6 and 62.3), nitrogen build up (18.7 kg/ha) and net returns (Rs.71608 and Rs.71090 /ha) with a benefit –cost ratio of 2.54 and 2.32 during the year 2008-09 and 2009-10, respectively were higher in the sequence where mustard was intercropped with fieldpea when succeeded by maize grown in association with cowpea followed by the sequence mustard+fieldpea succeeded by maize in association with moongbean intercropping sequences.

**Keywords:** *mustard-maize intercropping sequences, kandi areas, system productivity, climate smart agriculture, North-western-Himalayas*

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## 1. Introduction

Indian sub-continent predominantly represents wide spectrum of climate ranging from arid to semi-arid, sub humid and humid with wider variation in rainfall amount and pattern. Seasonal temperature fluctuations are also vast [1]. Soils representing rainfed regions are marginally low in organic matter status. The first predominant cause of soil degradation in rainfed regions undoubtedly is water erosion [2]. The process of erosion sweeps away the topsoil along with organic matter and exposes the subsurface horizons. The second major indirect cause of degradation is loss of organic matter by virtue of temperature mediated fast decomposition of organic matter and robbing away of its fertility. Above all, the several other farming practices such as reckless tillage methods, harvest of every small component of biological produce and virtually no return of any plant residue back to the soil, burning of the existing residue in the field itself for preparation of clean seed bed, open grazing etc aggravate the process of soil degradation. Ensuring food security under a changing climate is one of the major challenges of the 21st Century. In 2010, about 925 million

people in the world were food insecure of which 16 per cent of population was in developing countries. Global population is projected to rise from 7 billion currently to over 9 billion by 2050, creating intense demand for a more diverse diet requiring additional resources. Competition for labour, land, water and energy will intensify in an attempt to meet the need for food, fodder, fuel and fibre, while globalization may further expose the food system to the vagaries of economic and political forces. Estimates indicate that global food production must increase by 70 – 100 per cent by 2050 to meet human demand. Agriculture is most vulnerable sector to climate change, more than any other major economic sector, it will need to adapt to the changing climate.

Under optimistic lower-end projections of global warming, climate change may reduce crop yields by between 10 and 20 per cent. Increasing temperatures and declining precipitation are already reducing yields of grains and other primary crops in many parts of the vast semi-arid tropics where so many of the poorest reside. Increased incidence of droughts, floods and pests may also lead to yield instability and a sharp increase in prices of major food crops. 1°C rise in temperature may reduce rice yields by 4-5 m t and wheat yields by 3-4 mt in India. Climate Smart Agriculture (CSA) tackles the food

insecurity and climate change problems together, rather than in isolation. It is a vital component of green growth that seeks to operationalize sustainable development by reconciling the need for rapid growth and poverty alleviation with the need to avoid irreversible and costly environmental damage. CSA strategies include improved technologies and innovation, resource efficient use of land, water, energy and other inputs, improved access to information and infrastructure, efficient markets and risk management tools.

In the state of Jammu and Kashmir which is also the part of North-western-Himalayas, rainfed agriculture is practiced over an area of 4.26 lakh ( $10^5$ ) hectares which represents 57.64 per cent of the net sown area of 7.39 lakh ( $10^5$ ) ( $10^5$ ) hectares in the state. Out of the total culturable area of 3.90 lakh ( $10^5$ ) hectares in Jammu region 75.25 per cent is rainfed. Therefore, intercropping is an important aspect than sole cropping to address the issues of rainfed (*kandi*) agriculture under climate changing scenario and it provides an insurance against calamities which helps in the maximization of productivity and profitability by efficient utilization of natural resources like land, light and water. The inclusion of legumes as intercrops in mustard under mustard pulse intercropping sequences would have a positive effect on the productivity, economics and fertility status of the soil in changing scenario of climate. Keeping in view the present study entitled "Mitigating food security options through climate resilient Mustard-Maize based Intercropping Sequences For North-Western-Himalayas" was undertaken to find out the suitable intercropping sequence that helps the farming community in changing climate scenario in Jammu region of north-western Himalayas.

## 2. Materials and Methods

The field experiments were conducted at Dry Land Research Sub-station of She-e Kashmir University of Agricultural Sciences and Technology, Jammu during *rabi* (*winter*) season of 2008-09 to *kharif* (*monsoon*) season of 2010 on the same site and layout. The experimental field was well drained upland with bulk density of 1.42g/cc. The soil of the experimental site was sandy loam with low in organic carbon (0.41%), available nitrogen (174.2 kg/ha) and medium in available phosphorus (16.50 kg/ha), potassium (124.0 kg/ha) and sulphur (20.4 kg/ha). The experiment on mustard-maize based intercropping sequence was planned with the objective to identify the most promising mustard-maize legume based intercropping sequence to improve and stabilize the productivity of subtropical *Kandi* areas of Jammu region under changing climate situations smartly. Initially the experiment was laid out in a Randomized block design in four replications by taking four mustard based intercropping systems viz., Sole mustard, mustard + fieldpea, mustard + chickpea and mustard + lentil as experimental treatments during *rabi* (*winter*) season and keeping the *rabi* (*winter*) imposed intercropping systems as main plot treatments for *Kharif*, four new maize based intercropping systems viz., Sole maize, maize + moongbean, maize + urdbean and maize + cowpea were introduced as sub-plot treatments. The crops were raised

on 9 and 11 November and 4<sup>th</sup> July and 25<sup>th</sup> June of respective *rabi* (*winter*) and *kharif* (*monsoon*) seasons of both the years with a crop geometry of 30 X 10 cm (mustard) and 75 X 20 cm (maize) and the crops were harvested on 25 March and 15 April during first and second *rabi* (*winter*) seasons whereas the *kharif* (*monsoon*) crops were harvested on 28 and 30, September of 2009 and 2010, respectively. The system productivity was calculated on the basis of mustard equivalent yield basis, production efficiency, net returns and benefit-cost ratios were estimate as per the standard formula of respective yield estimation parameters. To determine the uptake of nutrients especially nitrogen, phosphorus and potassium by plants and in the soil complex as per Micro Kjeldhal, Tri acid extraction followed by spectrophotometric method and Flame Photometry method, respectively for preparing the balance sheet of these nutrients.

The economics of cultivation of sixteen different mustard-maize legume based intercropping sequences was worked out taking into account the cost of inputs and outputs as per the prevailing market prices during the study period. The net returns for each treatment were calculated by deducting the cost of cultivation from the gross returns. net returns per rupee invested were worked out by dividing the gross returns with the cost of cultivation.

The rainfall trends during the crop growth periods revealed that a total of 694.7 and 1032.8 mm of rainfall was received during *rabi* (*winter*) 2008-09 to *kharif*, 2009 and *rabi* (*winter*) 2009-10 to *kharif*, 2010 respectively, with the second crop cycle registering 48.7 per cent higher total rainfall as compared to first cycle of crop. Out of the total rainfall of 694.7 and 1032.8 mm received during the crop growing period, 110.4 and 37.4 mm; and 584.3 and 995.4 mm were received during the *rabi* (*winter*) and *kharif* (*monsoon*) seasons of both the crop cycles, respectively.

## 3. Results and Discussion

### 3.1. Effect of Mustard-maize System Based Intercropping Sequences on Mustard Equivalent System Productivity and Production Efficiency

The data with respect to system productivity of different mustard-maize system based intercropping sequences on mustard equivalent yield basis and production efficiency (Table 1) revealed that all the intercropping systems recorded highest system productivity and production efficiency as compared to mustard-maize sequence taken in sole stand during both the years of experimentation. Amongst the different mustard-maize system based intercropping sequences mustard + fieldpea-maize + cowpea intercropping sequences recorded highest mustard equivalent system productivity of 4.70 and 4.91 q ha<sup>-1</sup> during the year 2008-09 and 2009-10, respectively. It was closely followed by the sequence mustard + fieldpea – maize + moongbean, mustard + chickpea – maize + cowpea, mustard + chickpea – maize + moongbean, mustard + fieldpea – maize + urdbean, mustard + chickpea –maize + urdbean, mustard + lentil – maize +

cowpea, mustard + lentil – maize + moongbean and mustard + lentil – maize + urdbean with their corresponding values of 4.65 and 4.66; 4.51 and 4.54; 43.6 and 4.41; 4.33 and 4.01; 4.21 and 4.12 ; 3.81 and 3.56; 3.70 and 3.73 and 3.46 and 3.40 in the descending

order of magnitude with sole mustard-sole maize sequence recording lowest system productivity of 2.59 and 2.56 q ha<sup>-1</sup> during the first and second year of experimentation, respectively.

**Table 1. System productivity (t/ ha) and production efficiency (Kg grains/ ha/ day) of mustard-maize system based intercropping sequences**

Cropping sequence	System productivity		Production Efficiency	
	2008-09	2009-10	2008-09	2009-10
Sole mustard-sole maize	2.59	2.56	30.6	38.5
Sole mustard-maize + moongbean	3.21	3.52	41.3	47.5
Sole mustard-maize + urdbean	2.96	3.17	37.8	44.2
Sole mustard-maize + cowpea	3.36	3.92	42.1	46.8
Mustard + fieldpea-sole maize	3.48	3.18	39.3	44.9
Mustard + fieldpea-maize + moongbean	4.65	4.54	58.2	60.3
Mustard + fieldpea-maize + urdbean	4.33	4.01	52.7	56.0
Mustard + fieldpea-maize + cowpea	4.70	4.91	59.6	62.3
Mustard + chickpea-sole maize	3.40	3.11	38.1	50.6
Mustard + chickpea-maize + moongbean	4.36	4.41	53.3	56.3
Mustard + chickpea-maize + urdbean	4.21	4.12	50.6	52.8
Mustard + chickpea-maize + cowpea	4.51	4.66	56.1	60.0
Mustard + lentil-sole maize	2.88	2.63	33.3	41.1
Mustard + lentil-Maize + moongbean	3.70	3.73	46.5	48.8
Mustard + lentil-maize + urdbean	3.46	3.40	43.0	47.8
Mustard + lentil-maize + cowpea	3.81	3.56	47.9	54.3

The treatment wise production efficiency values in the descending order of magnitude have been 59.6 and 62.3; 58.2 and 60.3; 56.1 and 60.0; 53.3 and 56.3; 52.7 and 56.3; 50.6 and 52.8; 47.9 and 54.3; 46.5 and 48.8 and 43.0 and 47.8 for the sequences mustard + fieldpea –maize + moongbean, mustard + chickpea – maize + cowpea, mustard + chickpea - maize + moongbean, mustard + fieldpea - maize + urdbean, mustard + chickpea-maize + urdbean, mustard + lentil- maize + cowpea, mustard + lentil-maize + moongbean and mustard + lentil - maize + urdbean with sole mustard-sole maize recording lowest production efficiency values of 30.6 and 38.5 Kg grains ha<sup>-1</sup>day<sup>-1</sup> during the year 2008-09 and 2009-10, respectively. This might be attributed to better utilization of resources and production of component crops in intercropping sequences. These results are in agreement with the findings of [3,4].

### 3.2. Effect of Mustard-maize System Based Intercropping Sequences on Economic Analysis

The sequence wise economic returns were worked out with the help of operating cost of operation/input of individual treatments of the crops in the sequence as well as on their respective gross returns (Table 2). The data in respect of cost of cultivation of individual clearly indicate that the cost of cultivation of the treatments in general enhanced with the increase in number of crops in the sequences and their management practices ranging from Rs 26646 to 28144 ha<sup>-1</sup> and Rs25200 to 26147 ha<sup>-1</sup> in case where four and three crops were involved in the sequence, respectively, whereas the lowest amount of Rs 23858 ha<sup>-1</sup> was involved where mustard and maize were taken in the sequences as sole crops. Gross return data of individual

treatments presented in Table 2 clearly advocated that the gross returns of the treatments in general enhanced with the increase in number of crops in the sequences ranging from Rs 99751 to 96870 ha<sup>-1</sup> and Rs76677 to 66003 ha<sup>-1</sup> in case where four and three crops were involved in the sequence, respectively, whereas the lowest gross returns of Rs 56578 ha<sup>-1</sup> was involved where mustard and maize were taken in the sequences as sole crops during the first year of experimentation. Amongst the different mustard-maize system based intercropping sequences, highest net returns were fetched by the sequence where mustard was intercropped with fieldpea succeeded by maize + cowpea intercropping sequence with Rs 71608 and 71090 ha<sup>-1</sup> during the years of 2008-09 and 2009-10, respectively. This sequence was closely followed by mustard + fieldpea - maize + moongbean intercropping sequence fetching higher net returns of Rs 69051 and 64420 ha<sup>-1</sup> during the first and second year of investigation, respectively. The net return values of other intercropping sequences recorded viz, mustard + fieldpea succeeded by maize + moongbean (Rs 69051 and 64420 ha<sup>-1</sup>), mustard + chickpea-maize + cowpea (Rs63196 and 64165 ha<sup>-1</sup>), mustard + fieldpea-maize + urdbean (Rs 61846 and 53842 ha<sup>-1</sup>) and mustard + chickpea-maize + moongbean(Rs 61775 and 60867 ha<sup>-1</sup>) during both the years of 2008-09 and 2009-10 . The lowest net returns were obtained with the treatment where sole mustard followed by sole maize in the sequences with Rs32720 and 29874 ha<sup>-1</sup> in first and second year, respectively. Among the different treatments highest benefit cost ratio i.e, rupee per rupee investment was realized under the sequence where mustard + fieldpea–maize + cowpea intercropping sequence was taken having benefit cost ratio values of 2.54 and 2.32 during first year and second year of investigation, respectively. Intercropping sequences realized higher

benefit cost ratio as compared to sole stands of mustard + maize in the sequences. Further, it was also noticed that more the involvement of crops in the intercropping sequences higher were the benefit cost ratio. This might be attributed to higher mustard and maize equivalent yields resulting higher net returns achieved from this treatment

besides higher cost of cultivation involved under the same intercropping sequence than sole mustard-sole maize sequence. [5,6,7] also reported the economic viability and profitability of intercropping systems over sole cropping system.

**Table 2. Economic analysis (Rs/ha) of mustard and maize based intercropping sequences over the years**

Cropping sequences	Cost of cultivation (a)		Gross returns(b)		Net returns (c=b-a)		B:C ratio (d=c/a)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Sole mustard-sole maize	23858	25794	56578	55667	32720	29874	1.37	1.16
Sole mustard-maize + moongbean	25530	27445	70864	75088	45334	47644	1.78	1.74
Sole mustard-maize + urdbean	25200	27115	66003	68675	40803	41560	1.62	1.53
Sole mustard-maize + cowpea	25855	27770	76677	84926	50822	57156	1.97	2.06
Mustard + fieldpea-sole maize	26147	28609	70892	64828	44745	36219	1.71	1.27
Mustard + fieldpea-maize + moongbean	27819	30260	96870	94480	69051	64420	2.48	2.12
Mustard + fieldpea-maize + urdbean	27489	29930	89332	83772	61843	53842	2.25	1.80
Mustard + fieldpea-maize + cowpea	28144	30585	99751	101675	71608	71090	2.54	2.32
Mustard + chickpea-sole maize	25878	28329	70151	66590	44273	38261	1.71	1.35
Mustard + chickpea-maize + moongbean	27550	29980	89325	90847	61775	60867	2.24	2.03
Mustard + chickpea-maize + urdbean	27220	29650	86408	85722	59188	56072	2.17	1.89
Mustard + chickpea-maize + cowpea	27875	30305	91071	94470	63196	64165	2.27	2.11
Mustard + lentil-sole maize	25304	27754	70824	63085	45520	35331	1.80	1.27
Mustard + lentil-maize + moongbean	26976	29405	71440	79401	44464	49995	1.65	1.70
Mustard + lentil-maize + urdbean	26646	29075	78721	79494	52075	50419	1.95	1.73
Mustard + lentil-maize + cowpea	27301	29730	84970	92116	57669	62386	2.11	2.10

### 3.3. Effect of mustard-maize System Based Intercropping Sequences on Balance of Nutrients

The results of the estimation made to arrive at an appropriate balance sheet of available nitrogen, phosphorus, and potassium, as affected by different mustard-maize based cropping sequences over the two year period are presented in Table 3 revealed that irrespective of the intercropping treatment there was depletion of P, and K content. However, considerable improvement in nitrogen was recorded with all intercropping treatments over sole-sole cropping system. Balance sheet of available soil nitrogen based on initial and actual soil status after two years crop cycles, was positive under all the intercropping sequences. It is evident from the data given in the Table 3 that the different mustard-maize system based intercropping sequences influenced the availability of nitrogen content in the soil. In general, the highest values of available nitrogen over its initial status were recorded in the cropping sequence having legumes as one of the components in both the sequence and negative one in others where no legume was involved. After the completion of two crop cycles, the intercropping sequence where mustard in association with fieldpea was succeeded by maize grown in combination with cowpea recorded higher recovery of available nitrogen with a net buildup of 18.7 Kg/ha followed by the sequence mustard taken with chickpea succeeded by maize with cowpea with a buildup of 14.8 Kg/ha. However, the sole mustard-sole maize recorded negative influence with a depletion of 3.9Kg/ha. The balance of nitrogen under other cropping sequences was also positive ranging from 3.1 to 11.1 Kg/ha. Balance sheet of available phosphorus as influenced by different intercropping sequences presented in Table 3 envisaged that the different mustard-maize system based

intercropping sequences influenced the availability of phosphorus content in the soil after the completion of cropping sequences. A perusal of the data of expected and actual balance of available phosphorus over a period of two years revealed that the cropping sequence where mustard + fieldpea succeeded by maize + cowpea intercropping showed depletion of 1.1 Kg/ha followed by mustard + chickpea-maize + cowpea (0.7 Kg/ha) intercropping sequence. However, there was buildup of 2.3 Kg/hain sole mustard succeeded by sole maize. It is evident from the data given in the Table 3 that the different mustard-maize system based intercropping sequences influenced the availability of potassium content in the soil when observed after completion of experiments. On comparing the expected and actual balance of available soil potassium content, depletion of available potassium was noticed in all the intercropping sequences except where sole-sole cropping sequence where it was found to be positive. It varied from -1.0 to -11 Kg/ha. After completion of two cropping cycles, the intercropping sequence where mustard in association with fieldpea was succeeded by maize + cowpea recorded higher depletion of available potassium with a net depletion value of 11.0 Kg/ha followed by the sequence mustard taken with chickpea succeeded by maize with cowpea with a depletion value of 9.00 Kg/ha. This might have happened due to good growth of legume crop (fieldpea and cowpea) helps in higher number of nodules plant<sup>-1</sup> and subsequently higher nodule weight and good nodulation may have contributed for higher nitrogen fixation and resulted in more availability of residual nitrogen in the soil [8,9,10] also reported similar results. However, higher removal of nutrients (P and K) by mustard-maize system based intercropping systems might have the reason behind low concentration of these available nutrients in soil. Similar results were also reported by [5,6,11,12].

**Table 3. Balance sheet of available N, P and K in soil under mustard-maize system based intercropping sequences over a period of two years (Kg/ha)**

Cropping sequences	Addition			Removal by crops			Expected balance in soil			Actual balance in the soil			Build up/depletion over the initial status		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Sole mustard-sole maize	240	140	70	245.6	67.6	192.3	168.58	88.86	1.63	170.3	18.8	125	-3.9	+2.3	+1
Sole mustard-maize+moongbean	240	140	70	350.9	94.4	232.2	63.24	62.06	-38.24	179.6	16.8	123	+5.4	+0.3	-1
Sole mustard-maize+urdbean	240	140	70	330.8	89.2	217.2	83.40	67.33	-23.21	178.2	16.9	122	+4.0	+0.4	-2
Sole mustard-maize+cowpea	240	140	70	400.6	115.6	251.2	13.58	40.91	-57.22	182.3	16.8	118	+8.1	+0.3	-6
Mustard+fieldpea-sole maize	240	140	70	320.0	83.4	251.1	94.19	73.1	-57.11	178.7	17.2	117	+4.5	+0.7	-7
Mustard+fieldpea-maize+moongbean	240	140	70	425.3	110.2	290.9	-11.15	46.3	-96.98	185.3	18.5	116	+11.1	+2.0	-8
Mustard+fieldpea-maize+urdbean	240	140	70	405.2	104.9	275.9	9.01	51.57	-81.95	180.2	18.1	118	+6.0	+1.6	-6
Mustard+fieldpea-maize+cowpea	240	140	70	475.0	131.3	309.9	-60.81	25.15	-115.96	192.9	15.4	113	+18.7	-1.1	-11
Mustard+chickpea-sole maize	240	140	70	263.2	73.3	231.1	150.99	83.18	-37.12	180.3	17.9	121	+6.1	+1.4	-3
Mustard+chickpea-maize+moongbean	240	140	70	368.6	100.1	270.9	45.66	56.38	-76.99	181.6	16.7	118	+7.4	+0.2	-6
Mustard+chickpea-maize+urdbean	240	140	70	348.4	94.8	255.9	65.81	61.65	-61.96	179.6	17.9	120	+5.4	+1.4	-4
Mustard+chickpea-maize+cowpea	240	140	70	418.2	121.2	289.9	-4.01	35.23	-95.97	189	15.8	115	+14.8	-0.7	-9
Mustard+lentil-sole maize	240	140	70	282.1	68.6	232.8	132.08	87.86	-38.89	177.3	16.8	122	+3.1	+0.3	-2
Mustard+lentil-Maize+moongbean	240	140	70	387.5	95.4	272.7	26.75	61.06	-78.76	179.8	16.8	120	+5.6	+0.3	-4
Mustard+lentil-maize+urdbean	240	140	70	367.3	90.2	257.7	46.90	66.33	-63.73	178.6	17.9	123	+4.4	+1.4	-1
Mustard+lentil-maize+cowpea	240	140	70	437.1	116.6	291.7	-22.92	39.91	-97.74	183.6	16.7	121	+9.4	+0.2	-3
Initial status (Kg/ha)	174.2	16.5	124												

The rainfall trends during the crop growth periods revealed that a total of 694.7 and 1032.8 mm of rainfall was received during *rabi (winter)* 2008-09 to *kharif*, 2009 and *rabi (winter)* 2009-10 to *kharif*, 2010, respectively with the second crop cycle registering 48.7 per cent higher total rainfall as compared to first cycle of crop. Out of the total rainfall of 694.7 and 1032.8 mm received during the crop growing period, 110.4 and 37.4 mm; and 584.3 and 995.4 mm were received during the *rabi (winter)* and *kharif (monsoon)* seasons of both the crop cycles, respectively. The amount of rainfall as recorded during *rabi (winter)* seasons of 2008-09 (116.4mm) and 2009-10 (37.4 mm) were found to be quite less as compared to the average seasonal rainfall (165.8 mm) of the experimental site which is typically a true representative of sub-tropical *kandi* belt of Jammu region. Moreover, there appeared to be large variation in the distribution system of rainfall between two seasons as about 67.4 percent of total rainfall was recorded in only two meteorological weeks (1<sup>st</sup> and 6<sup>th</sup>) in the month of January during crop growing season of *rabi (winter)* 2009-10. The receipt of less rainfall as compared to the seasonal average in both the crop growing seasons accompanied with its ill distribution system, in general, might have affected the overall performance of both the base and the intercrops irrespective of the treatments. The drastic reduction in growth, yield attributes (plants metre<sup>-2</sup>, number of siliquae/pods plant<sup>-1</sup>, number of seeds siliqua<sup>-1</sup>/pod<sup>-1</sup> and 1000 seed weight) and yield of both the main and intercrops (fieldpea, cowpea and chickpea) during second

*rabi (winter)* (2009-10) over as recorded in first *rabi (winter)* (2008-09) irrespective of the treatments might be ascribed to dry spells occurred at peak water requiring stages of mustard and its intercrops (flowering, siliquae/pods development and seed filing stage) due to low rainfall as well as its improper distribution.

As regards the *kharif (monsoon)* seasons, the crop growing periods of 2009 and 2010 received about 584.3 and 995.4 mm of rainfall, respectively. The rainfall received during *kharif (monsoon)* season of 2009 was not only unevenly distributed but it was also found below the seasonal average of 750 mm and further most of it was received during 29<sup>th</sup> to 32<sup>nd</sup> (81.48 per cent of total rainfall) standard meteorological week, which relatively resulted in drier crop growing season for a longer period with lower values of relative humidity (RH) and higher values of pan evaporation. The substantial reduction in growth, yield attributes (plant population, number of grains cob<sup>-1</sup>/seeds pod<sup>-1</sup> and 1000 grain/seed weight) and yield of maize and its intercrops (cowpea, moongbean and urdbean) taken during *kharif* 2009 over that of *kharif (monsoon)* 2010 in general i.e. irrespective of the treatments might also have happened due to less rainfall as well as its ill distribution system during the crop growing period of *kharif (monsoon)* 2009. Similar findings about the influence of the amount and distribution system of rainfall on crop yields to a great extent have also been reported by [13,14] for different crops. The weather conditions during the crop growing seasons are given in the Figure 1 and Figure 2.

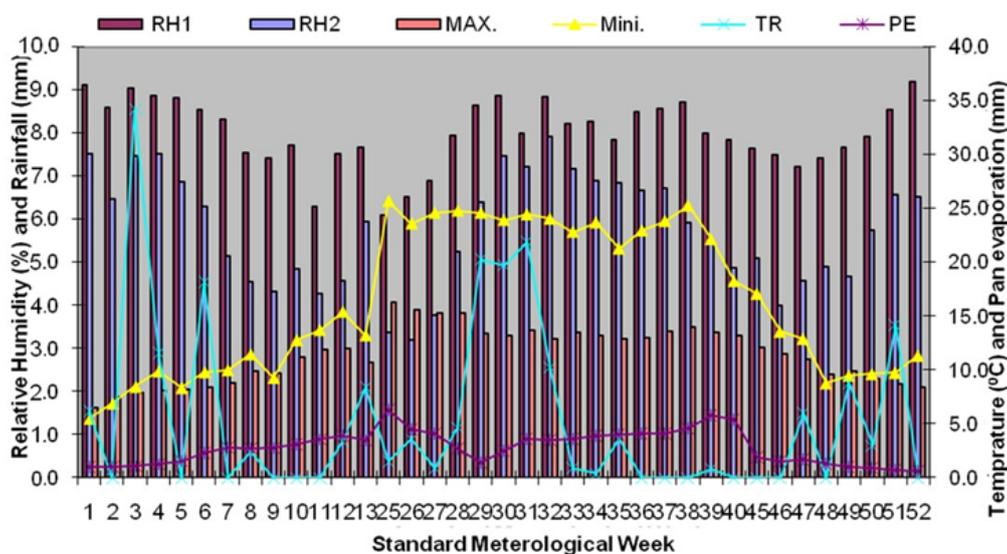


Figure 1. Weather parameters prevailing during the crop season 2008-09

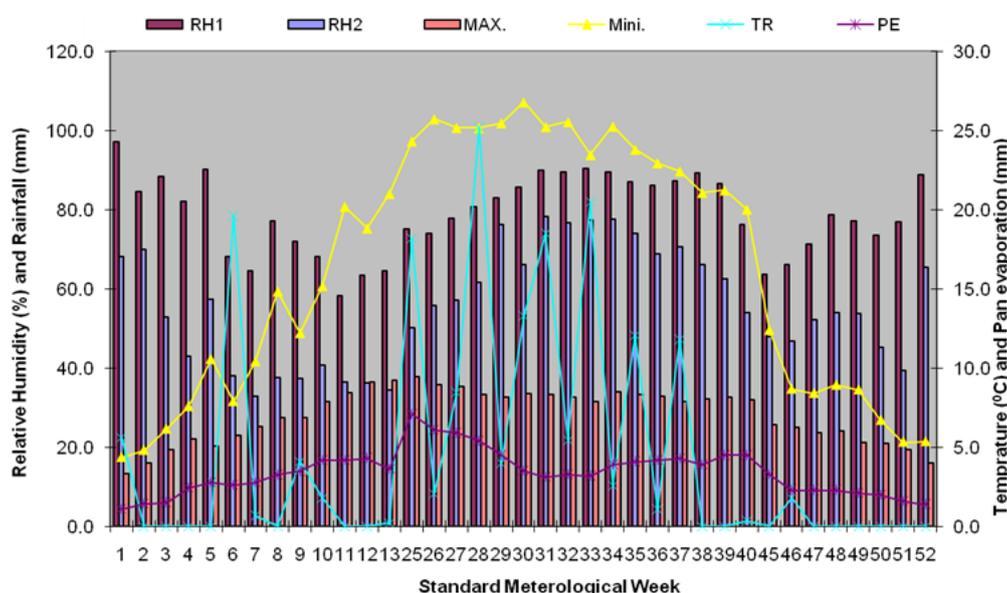


Figure 2. Weather parameters prevailing during the crop season 2009-10

It can be concluded that among the sixteen different mustard–maize based intercropping sequence under study, the intercropping sequence where mustard in association with fieldpea in *rabi* (winter) season succeeded by maize in combination with cowpea during *kharif* (monsoon) season was identified as promising intercropping sequence than sole mustard- sole maize cropping sequence (farmer practice) as climate smart agriculture option which will help in enhancing food security of resource poor farmers of Jammu region of North-Western –Himalaya . Such types of new agronomic intervention in Agriculture system can help in improving socio-economic status of the farmers of the region under climate resilient situation.

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