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Seasonal quantitative analysis of medium range rainfall forecast for south-western region of Punjab

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Abstract

The value added medium range rainfall forecast, received from Meteorological Centre, Chandigarh, was verified as per quantitative analysis three categories i.e. 0mm (no rainfall), 1-10mm, and more than 10mm rainfall for Bathinda (BTI) and Faridkot (FDK), districts of South-Western region of Punjab. Moreover, the seasonal skill of the rainfall forecast was also performed using Ratio score and Hansen Kuipers score analysis for both the study locations during 2013-14 to 2017-18. The results revealed that, among seasons, an average forecast for the dry weather (no rainfall), 1-10mm and >10mm was found to be successful in the ranged between 91-98, 11-50 and 100 per cent, respectively, while, 23 per cent successful for whole year for Bathinda. Similarly, for Faridkot, the forecast accuracy for no rainfall, 1-10mm and >10mm from 2013-14 to 2017-18 were found between 91-98, 17-60 and 100 per cent, respectively. Among the seasons, the highest HK score was recorded with post-monsoon (0.66) and winter season (0.68) for Bathinda and Faridkot, respectively, that indicated good skill of the rainfall forecast during the period, while, poor skill of the forecast was found with monsoon season for both the locations. Ratio score was also found to be higher for post-monsoon season (BTI 97.56 and FDK 97.24) indicating better skill of forecast, while, lowest with monsoon season.

Keywords: Medium range rainfall forecast, verification, ratio score, HK score

Introduction

In agricultural system, weather plays an important role in quality crop production. Moreover, the finest weather conditions throughout the crop season perform a critical role for sustainable agriculture and crop production. The weather variability is regarded as the major culprit of year-to-year fluctuations in crop yields, whereas, weather statistics, over time and space are more relevant when considering crop production at an aggregate spatial scale (Kumar *et al* 2004) ^[1].

The agricultural production in India is mostly depends on the South-West monsoon. Forecasting the onset of monsoon is therefore important for crop management and for sowing. Prediction of rainfall during winter season is also considerable importance for the Rabi crops in the northern and central parts of the country.

A timely medium range rainfall forecast provides tremendous benefits for appropriate management of aberrant weather. Farmers could thereby adjust their cropping patterns and plan agricultural operations in order to obtain maximum production even during adverse weather conditions. Weather forecasts can significantly contribute to food and livelihood security by providing advance information to adjust critical agricultural decisions e.g., irrigation, fertilizer, weed control, planting, harvesting (Apipattanavis *et al* 2010) ^[2].

Weather forecast can help farmers to take intelligent decisions about selection of crops, date of crop sowing/ planting and crop preventive measures to maximize the crop yields, so that, they can get benefit from good seasons and minimize the adverse effect of climate for their crops (Lunagaria *et al* 2009) ^[3]. More than 60 % farmers realized that the weather prediction and Agromet Advisory Services (AAS) to be useful for irrigation time, fertilizer time, pest and disease management and also for harvesting of crops (Khichar and Bishnoi, 2003) ^[4].

The reliability and accuracy of medium range weather forecast were studied time to time by several authors (Khichar and Bishnoi 2003 ^[4], Tripathi *et al* 2008 ^[5], Chauhan *et al* 2008 ^[6] Lunagaria *et al* 2009 ^[3]) for different Agro climatic zones of India. In present investigation, an attempt has been made to verify the quantitative analysis of medium range rainfall forecast in South-Western region of Punjab.

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Materials and methods

Medium Range Rainfall Forecast (MRRF) indicates weather forecast for 5 days in advance along with two days of outlook. The value added MRRF was obtained from Meteorological Centre, Chandigarh for Bathinda (latitude 30°58'N, longitude 74°18'E and altitude 211m above mean sea level) and Faridkot (latitude 30°40' N, longitude 74°44' E and altitude 200m above mean sea level) for five years from 2013-14 to 2017-18. However, actual rainfall data was obtained from the Agrometeorological Observatories of the respective stations (Bathinda and Faridkot) during the period.

Verification of medium range rainfall forecast

Seasonal analysis of rainfall forecast was carried out into four seasons as per standard of India Meteorological Department (IMD) i.e. pre-monsoon season (April - May), monsoon season (June - September), post-monsoon season (October – January) and winter season (February – March) on the basis of daily observed and forecasted rainfall data of Bathinda and Faridkot. Furthermore, season-wise quantitative analysis of medium range rainfall forecast was done under three categories of rainfall i.e. zero (0mm) rainfall category (i), 1-10mm rainfall categories (ii) and more than 10mm (>10mm) category (iii) which are presented in table 1 and depicted in figure 1.

Skill score analysis of medium range weather forecast

Based on the 2x2 contingency table, Ratio score and Hansen and Kuipers (H.K.) score were also determined for qualitative analysis of the rainfall forecast in order to know the skill of the forecast by using the following formulae. The value of Ratio score ranges between 0 to 100, where, 0 indicates no skill and 100 indicates perfect score and good forecast skill. Similarly, the value of HK score ranges between -1 to +1, where, 0 indicates no skill and +1 indicates ideal forecast skill.

$$\text{Ratio score} = \frac{(YY + NN)}{(YY + NN + YN + NY)} \times 100$$

$$\text{H.K. score} = \frac{(YY \times NN) - (YN \times NY)}{(YY + YN)(NY + NN)}$$

Where, YY= Number of days when rain was forecasted as well as observed

YN= Number of days when rain was forecasted but not observed

NY= Number of days when rain was not forecasted but observed

NN= Number of days when rain was neither forecasted nor observed

Results and Discussion

Quantitative verification analysis of medium range rainfall forecast for Bathinda

The season-wise quantitative analysis of rainfall forecast during 2013-14 to 2017-18 is given in table 1 and depicted in figure 1. The results revealed that the forecast for the dry weather (no rainfall) was found between 94-98, 87-98, 97-100, 86-100 and 94-98 per cent successful for pre-monsoon, monsoon, post-monsoon, winter season and whole year, respectively. Among the seasons, the forecast success for 1-10 mm rainfall observed highest i.e., 100 per cent during pre-monsoon season during 2016-17 and lowest during post-

monsoon and winter season (2015-16). In respect of more than 10mm rainfall, the forecast was found 100 per cent successful during pre-monsoon from 2014-15 to 2017-18, while, it was ranged between 32-71 per cent during monsoon season. For post-monsoon and winter season, the forecast success was ranged between 0-50 and 50-67 per cent, respectively. During whole year, the rainfall forecast success for 1-10 mm ranged between 09-43 per cent. The overall accuracy of rainfall forecast ranged between 89-98, 49-82, 95-98, 78-98 and 79-89 per cent for pre-monsoon, monsoon, post-monsoon, winter season and whole year, respectively. Chauhan *et al* (2008) ^[6] and Das and Desai (2018) ^[7] showed that the accuracy of rainfall was better in winter season and pre & post monsoon seasons. However, throughout monsoon, the accuracy of rainfall forecast indicated lower accuracy. Rana *et al* (2013) ^[8] also verified the rainfall forecast and found maximum RMSE of 27.1 was recorded in South West monsoon season indicating lower accuracy.

Quantitative verification analysis of medium range rainfall forecast for Faridkot

The forecast accuracy of rainfall over actual rainfall from 2013-14 to 2017-18 is given in table 1 and depicted in figure 1. The forecast for the no rainfall category was found between 94-98, 87-98, 97-99, 86-100 and 88-98 per cent successful for pre-monsoon, monsoon, post-monsoon, winter season and whole year, respectively. The forecast success for 1-10 mm rainfall observed highest i.e. 100 per cent during post-monsoon season (2014-15 and 2016-17) and lowest during pre-monsoon (2014-15) and post-monsoon season (2015-16). During whole year, the rainfall forecast success for 1-10 mm ranged between 14-33 per cent. The overall accuracy of rainfall forecast ranged between 56-97, 63-86, 94-98, 78-98 and 84-90 per cent successful for pre-monsoon, monsoon, post-monsoon, winter season and whole year, respectively.

Skill score analysis of medium range rainfall forecast for Bathinda

The skill score analysis of medium range weather forecast based on H.K. score and Ratio score during 2013-14 to 2017-18 is given in table 2 and depicted in figure 2. The results revealed that the average HK score was accounted as 0.61, 0.42, 0.66 and 0.54, while, ratio score were achieved to 94.10, 74.10, 97.56 and 89.54 per cent for pre-monsoon, monsoon, post-monsoon and winter season, respectively, which indicated better skill of the rainfall forecast. However, H.K score of 5 years from 2013-14 to 2017-18 ranged between 0.43-0.75, 0.26-0.56, 0.31-0.99, 0.17-0.98 and 0.51-0.74 for pre-monsoon, monsoon, post-monsoon, winter season and whole year, respectively. On the other hand, the Ratio score found highest 99.19 per cent for post-monsoon season during 2013-14 and lowest 75.41 per cent for monsoon season during 2015-16. Das and Desai (2018) ^[7] also revealed that the HK score in post monsoon and winter seasons found accuracy of rainfall forecasts nearly 100 percent correct in among seasons. Saulo and Ferreira (2003) ^[9] also verified the precipitation forecast and found that more realistic depiction of model performance with better skill of the forecast. Singh and Bhardwaj (2012) ^[10] depicted that ratio score on yearly basis was highest (74.6) during 2005-06 followed by 2004-05 (72.9) and 2003-04 (72.7), while, the value of H.K. score ranged between 24 and 42. Chauhan *et al* (2008) ^[6] also showed that the accuracy of rainfall forecast became useful in pre-monsoon and winter seasons having good HK score. Khicher *et al* (2010) ^[11] reported that the ratio score of rainfall was more than 86 percent and it shows better accuracy of rainfall forecast.

Skill score analysis of medium range rainfall forecast for Faridkot

The skill of medium range rainfall forecast based on H.K. score and Ratio score during 2013-14 to 2017-18 is given in table 2 and depicted in figure 2. Among different seasons, the average HK score in respect of rainfall were observed as 0.48, 0.42, 0.52 and 0.68, while, ratio score were accounted as 92.46, 77.54, 97.24 and 91.23 per cent for pre-monsoon,

monsoon, post-monsoon and winter season, respectively. However, H.K score of 5 years from 2013-14 to 2017-18 ranged between 0.16-0.80, 0.28-0.60, 0.22-0.80, 0.33-0.96 and 0.36-0.77 for pre-monsoon, monsoon, post-monsoon, winter season and whole year, respectively. On the other hand, the ratio score found highest 99.19 per cent for post-monsoon season (2016-17) and lowest for monsoon season (66.39 per cent) during 2017-18.

Table 1 Season-wise quantitative verification of medium range rainfall forecast from 2013-14 to 2017-18 for Bathinda and Faridkot

Rainfall	Bathinda					Faridkot				
	2013-14	2014-15	2015-16	2016-17	2017-18	2013-14	2014-15	2015-16	2016-17	2017-18
Pre-monsoon season (Apr-May)										
0 (No rain)	98	96	96	98	94	96	94	95	98	95
01-Oct	67	50	25	100	33	50	0	50	67	0
>10	0	100	100	100	100	100	0	0	100	100
Overall	97	92	92	98	89	92	84	56	97	87
Monsoon season (Jun-Sept)										
0 (No rain)	90	90	87	96	98	90	89	87	96	98
01-Oct	40	15	8	12	4	15	17	5	16	22
>10	63	71	32	60	44	63	100	42	83	50
Overall	82	81	62	70	49	80	86	69	74	63
Post-monsoon season (Oct-Jan)										
0 (No rain)	100	97	98	99	99	97	97	97	99	99
01-Oct	67	50	0	67	50	50	100	0	100	75
>10	50	0	0	0	0	0	0	0	0	0
Overall	98	96	95	98	97	97	97	94	98	98
Winter-season (Feb-Mar)										
0 (No rain)	86	96	89	100	96	98	86	93	100	100
01-Oct	29	44	0	75	25	56	20	66	80	67
>10	0	67	50	0	0	75	50	67	0	100
Overall	78	86	85	98	91	90	78	90	98	97
Whole year (Apr-Mar)										
0 (No rain)	94	95	94	98	96	95	92	93	88	98
01-Oct	43	34	9	26	11	38	20	14	33	27
>10	58	72	36	58	50	69	78	47	75	60
Overall	89	89	82	89	79	89	88	85	90	84

Table 2 Seasonal skill analysis (H.K score and Ratio Score) of medium range rainfall forecast for Bathinda and Faridkot

Seasons	2013-14	2014-15	2015-16	2016-17	2017-18	Average	2013-14	2014-15	2015-16	2016-17	2017-18	Average
	HK score (Bathinda)						Ratio score (Bathinda)					
Pre-monsoon (Apr-May)	0.75	0.68	0.45	0.75	0.43	0.61	98.36	93.44	91.80	98.36	88.52	94.10
Monsoon (Jun-Sep)	0.51	0.26	0.48	0.56	0.31	0.42	83.61	80.33	75.41	74.59	56.56	74.10
Post-monsoon (Oct-Jan)	0.99	0.49	0.31	0.74	0.78	0.66	99.19	96.75	95.93	98.37	97.56	97.56
Winter (Feb-Mar)	0.17	0.76	0.31	0.98	0.46	0.54	77.97	91.53	86.67	98.31	93.22	89.54
Whole year (Apr-Mar)	0.53	0.51	0.51	0.74	0.53	0.56	90.41	89.86	86.89	90.41	81.64	87.84
HK score (Faridkot)						Ratio score (Faridkot)						
Pre-monsoon (Apr-May)	0.68	0.52	0.23	0.80	0.16	0.48	93.44	90.16	93.44	98.36	86.89	92.46
Monsoon (Jun-Sep)	0.28	0.29	0.38	0.60	0.56	0.42	80.33	86.07	76.23	78.69	66.39	77.54
Post-monsoon (Oct-Jan)	0.49	0.33	0.22	0.80	0.74	0.52	96.75	96.75	95.12	99.19	98.37	97.24
Winter (Feb-Mar)	0.76	0.33	0.46	0.90	0.96	0.68	91.53	81.36	88.33	98.31	96.61	91.23
Whole year (Apr-Mar)	0.55	0.36	0.42	0.77	0.70	0.56	90.14	89.59	87.70	92.05	85.48	88.99

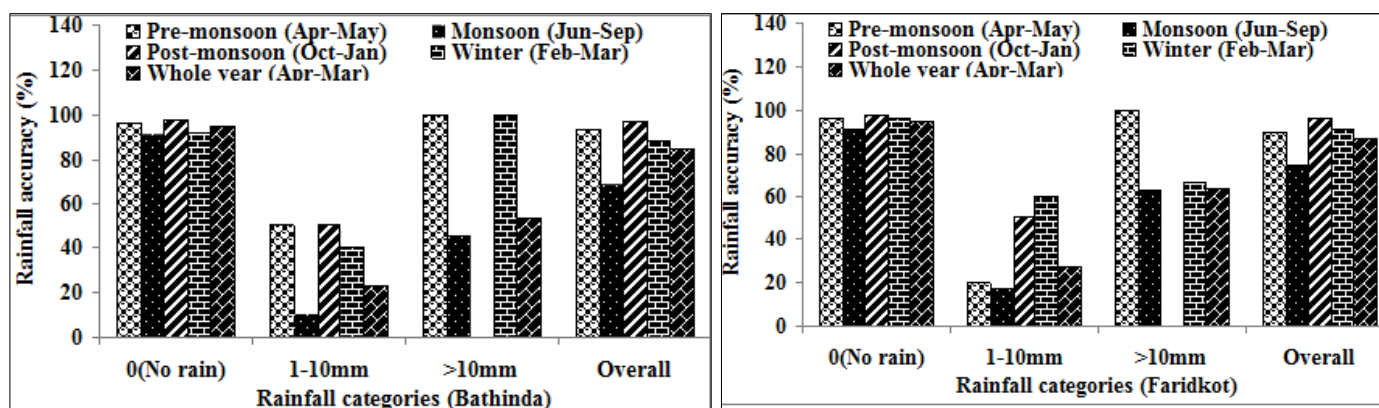


Fig. 1 Seasonal quantitative analysis of medium range rainfall forecast (average from 2013-14 to 2017-18) for Bathinda and Faridkot

Conclusion

The performance of the rainfall forecast as per quantitative analysis was quite good for all the seasons for no rainfall (91-98 per cent), while, forecast ranged between 11-60 per cent for rainfall 1-10 mm for both the regions. Moreover, in respect of more than 10 mm category of rainfall forecast, the accuracy was found between 0-100 per cent. Among the seasons, the highest HK Score was recorded with post-monsoon season (0.66) for Bathinda and winter season (0.68) in respect of Faridkot, while, maximum Ratio score was found as 97.56 and 97.24 per cent with post-monsoon season for Bathinda and Faridkot, respectively, which indicates better skill of the forecast. As per the good accuracy and better skill, the forecast of rainfall in terms of medium range can be used for selection of crops, date of crop sowing/ planting and crop preventive measures to maximize the crop yields, so that, they can get benefit and minimize the adverse effect of climate for their crops.

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