Carryover effect of green manure, FYM and N-fertilization on the succeeding wheat in rice-wheat cropping system

ABSTRACT

The present study was carried out Punjab Agricultural University, Regional Research Station, Gurdaspur, Punjab (India) during 2020-21 and 2021-22. The experiment was laid out in split-split plot design with three factors. Main plots contain three organic fertilizers treatments, sub plot contains three nitrogen levels and sub-sub plots contain three nitrogen application stage. Plant height of succeeding wheat crop grown after basmati rice was affected non-significantly by organic fertilizers and chemical fertilizers applied to basmati rice during both the years. The number of tillers and dry matter accumulation significant affected during both the years. Greater values were obtained with FYM application @ 15 t ha^{-1} whichwas significantly similar to green manuring but significantly higher than control during both the years. The various nitrogen doses and nitrogen application stages failed to significantly influence number of tillers and dry matter accumulation of succeeding wheat crop. In case of number of effective tillers and grains per spike, the maximum values were obtained with FYM. It was at par with green manuring but significantly higher than. The nitrogen doses and nitrogen application stages had non-significant effect on both these parameters. The organic fertilizers had statistical significant effect on straw and grain yield of wheat crop. The highest straw and grain yields were obtained with application of FYM @ 15 t ha^{-1} which wassignificantly higher than control but statistically at par with green manuring during both the years. The harvest index was non-significant for all the treatments. The total NPK uptake in wheat was significantly affected by the organic fertilizers. Highest uptake of NPK in grain and straw was observed with FYM application which was at par with green manuring but significantly higher than control during both the years.

Key words: Sunnhemp, FYM @15 t ha^{-1}, Nitrogen, Succeeding, Wheat

1. INTRODUCTION

In the Indo-Gangetic plains, wheat is grown under a rice-wheat cropping system. This system safeguards food security and livelihood in the Indian sub-continent, constituting a key part of protein and energy intake by humans (Singh *et al* 2012). However the productivity of the wheat crop in the rice-wheat cropping system has suffered due to poor rooting caused by subsoil compaction after puddling in rice (Gathala *et al* 2011). Further, the sustainability of the rice-wheat cropping system is under threat due to the non-judicious use of chemical fertilizers resulting in decreased soil organic carbon and multi-nutrient deficiencies along with reduced microbiological activity (Paul *et al* 2014). The yield under any cropping system and the balance between supply and demand of nutrients must be ensured by integrating the use of organic and inorganic fertilizers such as farm yard manure (FYM), green manure and synthetic fertilizers (Murali and Setty 2000). These organic manures not only provide rich nutrient supplies, but also improve the physical, chemical, and biological characteristics of the soil, thereby increasing nutrient availability. Apart from NPK, they also contain trace elements such as boron, copper, iron, sulphur, and zinc, as well as a decent number of growth-stimulating chemicals. Organic manures provide a controlled supply of nutrients by slowly releasing them it, resulting in higher yields and nutrient usage efficiency (Sharma 2002). After the wheat harvest, there is enough time in the basmati rice-wheat cropping system to incorporate organic fertilizer sources such as green manure (GM) and farmyard manure (FYM) into the system. As a result, in order to sustain high crop production levels, it is critical to enhance the effectiveness of chemical fertilizers through appropriate procedures and their combined usage with organic manure and green manure (Meelu *et al* 1994). Farmyard manure (FYM) is a significant component of bulky organic manures. The FYM application to soil enhances the biological, physical and chemical propertiesof the soil. Integration of organic sources into the nutrient management system can reduce the dependence upon chemical fertilizers and make agriculture environmentally and economically healthier. Currently, a major emphasis is being placed on planning the nutrient management strategy based on the entire cropping system rather than focusing on individual crops because succeeding crops are influenced by inputs applied to preceding crops (Ratanoo *et al.* 2022 and Devi et al. 2015). Keeping all these points in view, the present investigation was carried out to study the residual effect of green manure, FYM and N fertilization on the succeeding wheat crop

2. MATERIALS AND METHOD

The present study was carried out at the Punjab Agricultural University, Regional Research Station, Gurdaspur, Punjab (India) during 2020-21 and 2021-22. Gurdaspur is situated at 75°40' E longitude and 32°04' N latitude with an average height of 241m above sea level and is placed in the sub-mountainous region of Punjab. In the summer season the temperature reaches up to 44^{o}C or even sometimes crosses it. June is found as the hottest month and January is the coldest one. The normal annual rainfall of this region is about 1325 mm, 80 percent of which is usually received during the southwestern monsoon season and remaining during the winter season. The meteorological data recorded that the mean minimum weekly temperature varied between 4.7ºC to 21.2ºC and 3.9ºC to 23.6 ºC whereas the mean maximum weekly temperature varied between 14.5ºC to 36.2ºC and 13.6 ºC to 37.7 ºC during crop growing periods of *rabi* 2020-21 and 2021-22 respectively (fig 1&2). The amount of rainfall received during the growing season was 118.2 mm and 263.5 mm during *rabi* 2020-21 and 2021-22 respectively. Weekly hours of sunshine ranged from 1.1 to 7.6 and 0 to 7.9 during the crop seasons *rabi* 2020-21 and 2021-22 respectively. Rainfall was highest in the 17th SMW (43.5 mm) and 2nd SMW (88.1mm) during *rabi* 2020-21 and 2021-22 respectively.

The experiment was laid out in a split-split plot design with three factors. Main plots contains three organic fertilizer treatments (green manuring, rice farmyard manure@15tha^{-1}, and control: without green manuring and FYM), sub plot contain three nitrogen levels (100% recommended nitrogen, 75% recommended nitrogen and no nitrogen) and sub-sub plots contains three nitrogen application stage (recommended: equal dose at 3, 6 and 9 weeks after sowing, 50% basal + 25% at 4 weeks after sowing + 25% at 9 weeks after sowing and 50% basal + 25% at 3 weeks after sowing + 25% at 8 weeks after sowing). Sunnhemp (*Crotalaria juncea*) as a green manure crop was incorporated into the soil after 45 days of its sowing. Farmyard manure @15tha^{-1} was applied to the plots as per the treatments. The soil of the experiment is normal in pH (7.7), low in organic carbon (0.40 %), low in available nitrogen (135.5 kgha^{-1}), high in available phosphorus (22.7 kgha^{-1}) and low in potassium (99.3 kgha^{-1}). The recommended dose of fertilizers was applied to wheat crops during both years. Plant height and tillers of five randomly selected plants were recorded from each plot at harvest during both years. Dry matter accumulation by the crop was noticed at harvest using the plant destructive method and then expressed as g m^{-2}. The effective tillers were recorded at harvest from one-metre row length from two different sites in each plot. The count was converted into effective tillers m^{-2}. Five spikes were randomly selected from each plot and their length was measured from the base to the tip of the spike excluding awns. The length of five spikes was averaged and was expressed in cm. The number of grains per spike was counted from randomly selected ten ears at harvest and the data was expressed as a number of grains per spike by taking the mean value. The grain and straw yield was recorded in kilograms per plot and converted into q ha^{-1}. The harvest index was calculated as a percentage of grain yield to biological yield. Nitrogen content was determined by using a modified Kjeldahl's method proposed by Piper (1966). To determine phosphorus content, the Canada-molybdate phosphoric yellow color method in the nitric acid system was used as outlined by Jackson (1967). Potassium content was determined by using Lange's Flame Photometer (Jackson 1967).

3. RESULTS AND DISCUSSION

3.1 Growth characters

The data pertaining to plant height of wheat is presented in Table 1. The application of various organic fertilizers, nitrogen doses and its various split stages in direct-seeded basmati rice did not have a significant effect on the plant height of succeeding wheat crops during both years of study. To evaluate the residual effect of different organic fertilizers, nitrogen levels and nitrogen application stages, data on a periodic number of tillers per m^2 of wheat recorded at harvest are provided in Table 1. Among the organic fertilizers, FYM recorded the highest number of tillers m^{-2} which was at par with green manuring but significantly different from control during both the years. The nitrogen doses and nitrogen application stages did not have a significant effect on the number of tillers on succeeding wheat crop during both years. The higher number of tillers per m^2 might be due to the addition of nutrients by organic sources and their availability to the next crop due to slower decomposition rates. The significant residual effect on tillers of wheat has also been reported by Jat and Singh (2019). They reported that the highest number of tillers per meter row length was obtained in wheat with the application of FYM and press mud along with chemical fertilizers to the preceding rice crop. The data related to dry matter accumulation of wheat crops at various growth stages is depicted in Table 1. There was a significant effect of various organic fertilizers on this growth parameter during both years. FYM had the highest dry matter accumulation at these growth stages of the crop which was significantlysimilar to green manuring, but higher than control during both the years. FYM recorded 11% higher dry matter accumulation over control at harvest. The various nitrogen doses and nitrogen application stages had no significant carryover effect on dry matter accumulation of wheat during both years. The residual effect of organic sources of nutrients was noticed in wheat and recorded higher in dry matter accumulation of crops. The application of FYM and green manuring resulted in a higheramount of nutrients in soil for plant nutrition and further being as an organic source, continuous and slow release of nutrients enhanced cell elongation as well as various metabolic processes that increased plant growth attributes which ultimately helped in attaining the highest source capacity and dry matter accumulation. The significant residual effect of organic inputs in succeeding wheat crops in rice-wheat cropping system has also been reported by Latare *et al* (2014).

3.2 Yield attributes

The data (Table 2) revealed that various organic fertilizers had a significant residual effect on the effective tillers m^{-2} during both the years of study. The application of FYM recorded the highest number of effective tillers. It was significantly similar to green manuring but significantly higher than from control during both the years. The effective tillers were neither significantly influenced by nitrogen doses nor by nitrogen application stages. Jat and Singh (2019) also reported a significant residual effect of organic manures on effective tillers of wheat. They reported higher spikes per meter row length over control with the application of 70% recommended dose of fertilizer + 15% nitrogen by FYM + 15% nitrogen by poultry manure to the previous rice crop. These results are also corroborated by the findings of Kharub and Chander (2008). The data with respect to the spike length of wheat crop is presented in Table 2. The various organic fertilizers, nitrogen doses and nitrogen application stages failed to have any significant effect on the spike length of wheat. An examination of data (Table 1) revealed that the numbers of grains per spike were significantly affected by organic fertilizers. The application of FYM was on par with green manuring but substantially greater than the control and produced the most grains per spike during both the years. The number of grains per spike was not significantly affected by any nitrogen dose or nitrogen application stage. The steady and liberal supply of adequate nutrients by the organic manures during the crop growth period, thereby assisting in the fixation and translocation of more photosynthates from source to sink and increasing the number of grains per spike. Similar results were reported by Jat and Singh (2019).

3.3 Yield

The data pertaining to grain yield is presented in Table 3. The application of organic fertilizers had a significant residual effect on the grain yield of wheat. The highest grain yield was obtained with FYM which was at par with green manuring but significantly different from control during both the years. FYM recorded higher 10.7% and 11.7 % grain yield during 2020-21 and 2021-22 over control respectively. The nitrogen doses and nitrogen application stages had a non-significant effect on the grain yield of wheat. The organic fertilizers, nitrogen doses and nitrogen application stages had a non-significant interaction effect. The increase in grain yield might be attributed to a higher number of effective tillersand grains per panicle due to the residual effect of organic manures. Shah *et al* (2017) documented a 15.8%higher wheat grain yield in *Sesbania*-incorporated plot than in summer fallow. Similar results have also been reported by Hargilas and Sharma (2015). The data (Table 3) revealed that the straw yield of succeeding wheat crops was significantly influenced by the organic fertilizers applied to the preceding basmati rice. The application of FYM produced the highest straw yield which was significantly similar to green manuring but different than control during both the years. Higher plant height, dry matter accumulation, and tillers are examples of increased morphological growth parameters that may be indirectly linked to an increase in straw yield with integrated nutrient treatments. These findings concur with those made by Jat and Singh (2019) and Dwivedi *et al* (2005). The data related to the harvest index of the crop is depicted in Table 3. The harvest index varied from 43.1 to 44.0% and 43.1 to 44.7% during 2020-21 and 2021-22 respectively. The various organic fertilizers, nitrogen doses and nitrogen application stages failed to have any substantial impact on this index. Similarly, the interaction among different treatments was also non-significant.

3.4 Nutrients uptake

3.4.1 Nitrogen

Data on total nitrogen uptake by succeeding wheat crops are shown in Table 4. It was found that FYM application resulted in the highest total nitrogen uptake. It was comparable to green manuring but significantly much higher than control during both years of experimentation. The total nitrogen uptake was not impacted significantly by diverse nitrogen dosages or nitrogen application phases during both years. Organic fertilizers, nitrogen dosages, and nitrogen application stages had no significant interaction effect. Shah *et al* (2017) documented that residual organic treatments had a significant effect on nitrogen uptake in grain and straw by succeeding wheat.

3.4.2 Phosphorus

The total phosphorus uptake by succeeding wheat crop (Table 4) was also influenced by the organic fertilizers and the maximum value was recorded where FYM was applied @ 15 t ha^{-1}. It was significantly similar to green manuring but significantly higher than control during both years. The nitrogen doses and nitrogen application failed to exhibit significant influence over total phosphorus uptake during both years. No interaction effect among the various treatments was recorded. Higher grain yields, increased availability of phosphorus from organic sources, and the solubility effect of organic acids formed during their decomposition may all be contributing factors to increased P-uptake in crops. Shah *et al* (2017) documented that residual organic treatments had a significant effect on phosphorus uptake in grain and straw by succeeding wheat.

3.4.3 Potassium

The information on potassium uptake by succeeding wheat crops is shown in Table 4. The highest total potassium uptake by wheat grains was recorded with FYM application which was at par with GM but significantly different from control during both the years. There was no significant effect on potassium uptake in the case of nitrogen doses and nitrogen application stages during both years. The interaction effect among various treatments was non-significant. Potassium uptake in wheat can be attributed to better yields, organic supplies, and the solubility action of organic acids formed during the breakdown of organic materials, which led to more native potassium being released in the soil. Similar results have been reported by Sharma *et al* (1995) and Rathore *et al* (1995).

4. CONCLUSION

It was concluded that the growth parameters, yield attributes and yield of succeeding wheat crop in rice-wheat cropping system were significant affected with FYM application

@ 15 t ha^{-1} which was significantly similar to green manuring but significantly higher than control during both the years. The total NPK uptake in wheat was significantly affected by the organic fertilizers. Highest uptake of NPK in grain and straw in wheat was observed with FYM application which was at par with green manuring but significantly higher than control during both the years. The various nitrogen doses and nitrogen application stages in rice failed to significantly influence growth, yield, yield attributing characters and NPK uptake of succeeding wheat crop.

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Table 1: Residual effect of different organic fertilizers, nitrogen levels and nitrogen application stages in direct seeded basmati rice on growth characters of succeeding wheat crop

Treatment	Plant height (cm)		Tillers (No. m^{-2})		Dry matter accumulation (g m^{-2})	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Organic fertilizer applied to preceding DSBR						
Green manuring	102.8	104.5	371.9	378.2	1021.5	1030.4
Farmyard manure @15tha^{-1}	105.4	106.3	380.8	384.5	1045.2	1054.2
Control (Without green manuring and FYM)	100.6	102.1	359.0	362.4	967.3	986.8
CD (p=0.05)	NS	NS	11.6	9.6	24.0	27.3
Nitrogen doses applied to preceding DSBR						
100% recommended nitrogen	104.8	106.0	373.7	377.4	1018.0	1030.2
50% recommended nitrogen	102.4	103.6	370.7	374.5	1011.7	1028.6
Control (without nitrogen)	101.5	103.3	367.3	373.2	1004.4	1012.6
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen application stage in preceding DSBR						
Recommended (3, 6 and 9 weeks after sowing)	103.7	104.3	372.5	376.0	1015.4	1025.6
50% basal + 25% at 4 weeks after sowing + 25% at 9 weeks after sowing	102.8	105.4	370.0	375.1	1010.0	1029.5
50% basal + 25% at 3 weeks after sowing + 25% at 8 weeks after sowing	102.3	103.2	369.3	374.0	1008.7	1016.3
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS	NS

DSBR-Direct Seeded Basmati Rice

Table 2: Residual effect of different organic fertilizers, nitrogen levels and nitrogen application stages in direct seeded basmati rice on yield attributing characters of succeeding wheat crop

Treatment	Effective tillers ($No.\ m^{-2}$)		Spike length (cm)		Grains ($No.\ m^{-2}$)	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Organic fertilizer applied to preceding DSBR						
Green manuring	322.0	333.6	9.60	9.8	46.7	53.5
Farmyard manure @15tha^{-1}	329.0	345.0	9.95	10.0	48.6	54.9
Control (Without green manuring and FYM)	303.6	312.8	9.07	8.9	40.9	47.0
CD (p=0.05)	11.4	21.3	NS	NS	5.1	4.6
Nitrogen doses applied to preceding DSBR						
100% recommended nitrogen	323.1	335.8	9.88	9.8	46.9	52.7
50% recommended nitrogen	317.7	330.4	9.42	9.7	45.6	52.4
Control (without nitrogen)	313.8	325.2	9.31	9.2	43.7	50.3
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen application stage in preceding DSBR						
Recommended (3, 6 and 9 weeks after sowing)	320.9	332.4	9.64	9.5	46.2	52.6
50% basal + 25% at 4 weeks after sowing + 25% at 9 weeks after sowing	317.6	330.5	9.50	9.7	45.1	52.2
50% basal + 25% at 3 weeks after sowing + 25% at 8 weeks after sowing	316.1	328.5	9.48	9.5	44.8	50.6
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS	NS

DSBR-Direct Seeded Basmati Rice

Table 3: : Residual effect of different organic fertilizers, nitrogen levels and nitrogen application stages in direct seeded basmati rice on grain yield, straw yield and harvest index of succeeding wheat crop

Treatment	Grain yield(q ha^{-1})		Straw yield(q ha^{-1})		Harvest index(%)	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Organic fertilizer applied to preceding DSBR						
Green manuring	46.8	52.6	61.0	65.6	43.5	44.5
Farmyard manure @15tha^{-1}	48.6	53.2	63.5	68.2	44.0	44.7
Control (Without green manuring and FYM)	43.9	47.6	57.6	60.3	43.2	43.1
CD (p=0.05)	2.6	5.2	3.3	4.2	NS	NS
Nitrogen doses applied to preceding DSBR						
100% recommended nitrogen	46.7	51.2	61.9	64.5	43.9	44.3
50% recommended nitrogen	46.5	52.7	60.4	65.2	43.8	44.7
Control (without nitrogen)	46.1	49.5	59.7	63.4	43.1	43.8
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen application stage in preceding DSBR						
Recommended (3, 6 and 9 weeks after sowing)	46.6	51.4	61.4	65.3	43.3	44.0
50% basal + 25% at 4 weeks after sowing + 25% at 9 weeks after sowing	46.4	51.9	60.5	64.6	43.7	44.5
50% basal + 25% at 3 weeks after sowing + 25% at 8 weeks after sowing	46.3	50.1	60.1	63.2	43.8	44.2
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS	NS

DSBR-Direct Seeded Basmati Rice

Table 4: Residual effect of different organic fertilizers, nitrogen levels and nitrogen application stages in direct seeded basmati rice on total N, P and K uptake of wheat

Treatment	N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Organic fertilizer applied to preceding DSBR						
Green manuring	117.5	127.6	18.9	20.5	79.1	87.2
Farmyard manure @15tha^{-1}	128.5	133.2	20.6	22.3	85.4	92.8
Control (Without green manuring and FYM)	97.8	102.5	15.6	15.9	68.5	71.3
CD (p=0.05)	6.1	11.6	1.4	3.9	8.9	11.2
Nitrogen doses applied to preceding DSBR						
100% recommended nitrogen	117.1	125.0	18.8	21.4	79.4	85.4
50% recommended nitrogen	113.7	122.2	18.4	19.2	76.7	83.5
Control (without nitrogen)	112.6	119.1	17.9	18.1	74.9	82.4
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen application stage in preceding DSBR						
Recommended (3, 6 and 9 weeks after sowing)	116.3	124.3	18.5	20.9	78.7	84.6
50% basal + 25% at 4 weeks after sowing + 25% at 9 weeks after sowing	114.2	122.0	18.3	19.2	77.1	84.2
50% basal + 25% at 3 weeks after sowing + 25% at 8 weeks after sowing	113.3	120.0	18.3	18.6	76.4	82.5
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Interactions	NS	NS	NS	NS	NS	NS

DSBR-Direct Seeded Basmati Rice

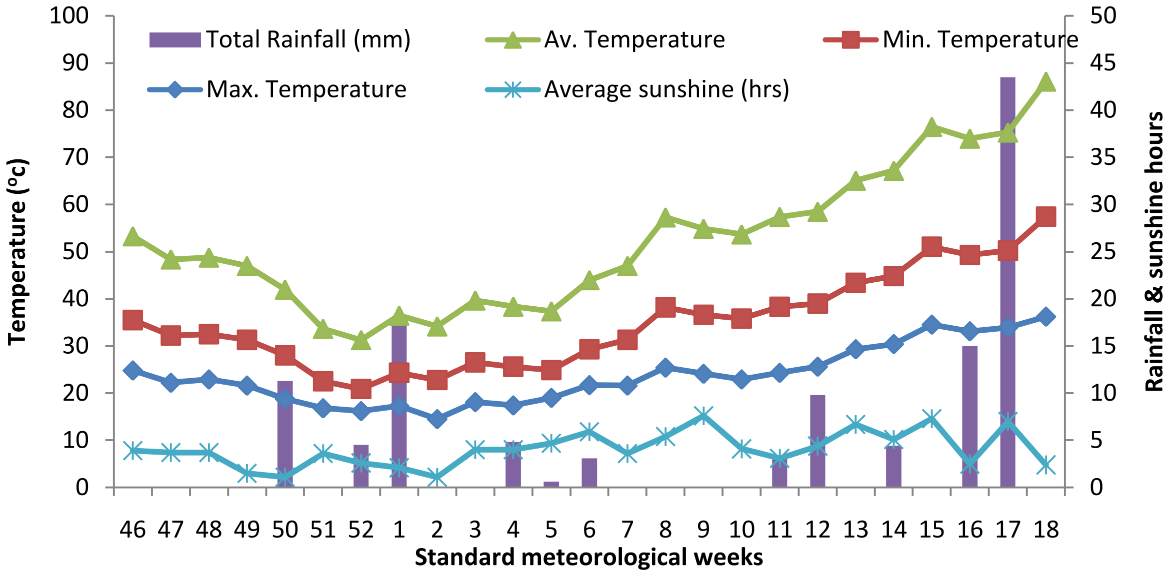

Fig. 1. Weekly mean meteorological data during the crop season in *rabi* 2020-21

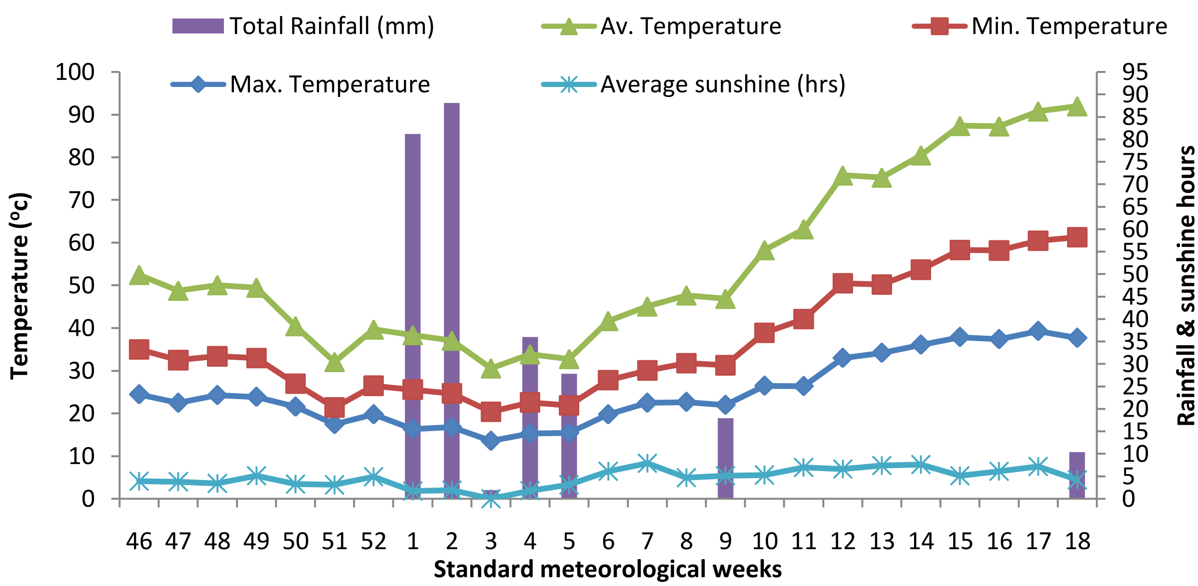

Fig. 2. Weekly mean meteorological data during the crop season in *rabi* 2021-22