Original Research Article

Interaction effect of Organic Manures and Alkali Water on Yield of Wheat

Abstract

Field experiment were carried out to investigate "Interactive effect of organic manures and Residual sodium carbonate (RSC) water on yield of wheat" in *rabi* season (November-April) 2019-20 and 2020-21 in the Field of Agronomy, SKN Agricultural University, Jobner, Jaipur, Rajasthan, India using Split Plot Design. The treatment consists three levels of alkali water (2, 6,10 RSC mmol L^{-1}), three organic manures (Control, FYM @15 t ha^{-1} and vermicompost @ 5 t ha^{-1}) in main plot and four levels of iron (Control, 50 kg, 100 kg and 150 kg $FeSO_4.7H_2O$ ha^{-1}) in sub plot were tested with three replications. Result showed that the irrigation with 10 mmol L^{-1} Residual sodium carbonate (RSC) water significantly decreased grain (26.02 q ha^{-1}) and straw yield (38.15 q ha^{-1}) of wheat in comparison to lower levels of RSC in water in wheat crop. Application of organic manures significantly increased grain yield of wheat during both the years and in pooled analysis. The highest grain (34.06 q ha^{-1}) and straw yield (51.60 q ha^{-1}) were obtained under vermicompost application and the effect of vermicompost (M_2) and FYM (M_1) application remained statistically at par with each other. ~~Interactive effect of RSC water and organic manures on grain and straw yield was found significant during both the years and in pooled.~~ Interactive effect of RSC water and organic manure application on grain and straw yields of wheat was found significant and maximum being with W_2 (2 mmol L^{-1} RSC), M_2 (vermicompost @ 5 t ha^{-1}) treatment combination indicating the magnitude of reduction in yields (grain and straw) being less with vermicompost and FYM at all the levels of RSC water.

Keywords:- FYM, RSC water, Vermicompost, Wheat

Introduction

In arid and semi-arid regions, the major constraints to agriculture are scarcity of water and poor-quality irrigation water. Over exploitation of groundwater for domestic and agricultural purposes are depleting good-quality water resources in arid and semiarid areas. Population of India is predicted to grow to 1.73 billion people by 2050 (Meena *et al*., 2021). Majority of population in developing countries already faces food shortage. This necessitates the use of saline/alkali water in agriculture. Salinity, sodicity and ion toxicity are major problems in irrigation waters particularly in arid areas where rainfall does not adequately leach salts from the soil and accumulation of salts occurs in the root zone of crops. The presence of excesses Na ion on clay complex results in the deterioration of soil structure, thereby reducing water penetration into and through the soil under sodic conditions. Sodium carbonate and bicarbonates are the most common salts found in alkali water. Long-term usage of such water causes soluble calcium and magnesium in the soil to precipitate as carbonates and immobilize them. In India, 6.73 million hectares of area has been characterized as salt-affected by ICAR-Central Soil Salinity Research Institute, Karnal. Out of which, 3.77 million hectares is alkali and the remaining 2.96 million hectares is saline, threatening the livelihood security of farming community (Kaledhonkar, *et al*., 2019). In Rajasthan, area falling under salt affected soils occupy 0.37 million hectares area. Out of this, 0.19 million hectares of land is suffering from salinity, while, 0.17 million hectares of land is suffering from sodicity (Singh, 2018). Soil sodicity influence the physiological, biochemical and morphological changes in plants, which represent the plant's overall performance. However, if inadequate minerals are made available to specific plant species, such as wheat, the most important rabi crop of salty regions, they may grow and yield well. Most saline sodic soils are generally poor in Ca, N, Zn, Mn, Cu, Fe and organic matter. (Singh *et al.,* 2013, Kumawat and Yadav 2013). Organic matter importance has been proven by its ability to improve the physical conditions of soils for crop development in addition to its role as fertilizer. The efficacy of various organic additions such as manure and compost in the restoration of salty sodic soils has been studied (Diez & Krauss 1997). Organic additions to soil reduce bulk density while increasing CEC and water holding capacity, resulting in a diluting impact on alkali soil. Organic matter works to prevent salt from building up in soils (Gupta *et al*., 1984). The microbial processes of nutrient immobilization and mineralization are strongly linked to organic matter dynamics and nutrient cycle.

Material and methods

The experiments were conducted at Agronomy Farm, S.K.N. College of Agriculture, Jobner (Rajasthan), Geographically Jobner is situated at $26^0$05´ North latitude and $75^0$28´ East longitude at an altitude of 427 meter above mean sea level (MSL). Maximum temperature in summer ranges between 28^0C to 44^0C, whereas temperature falls down to as low as 3^0C during winter. The average annual rainfall varies between 400 mm to 500 mm. The experiment comprised of 36 treatment combinations was replicated three time was laid out in split -plot design with three levels of alkali water (2, 6,10 RSC mmol L^{-1}), three organic manures (Control, FYM @15 t ha^{-1} and vermicompost @ 5 t ha^{-1}) in main plot and four levels of iron (Control, 50 kg, 100 kg and 150 kg $FeSO_4.7H_2O$ ha^{-1}) in sub plot were tested. The experiment soil was low in organic caron, available nitrogen, iron and medium in available phosphorous, potassium content in soil. Organic manures and iron were applied prior to sowing through $FeSO_4.7H_2O$ respectively as per treatments.

The variety Raj-4079 of wheat was used as the test crop. The seed were sown by kera method @ 120 kg ha^{-1} and the sowing was done on 11^{th} November 2019-2020 and 08^{th} November 2020-21 in first and second year, respectively. Observations were recorded grain yield per plot and straw yield per plot after complete drying the produce of individual plot. The grain and straw yield recorded under each plot were converted into quintals per hectare.

The experiment crop was irrigated by different RSC waters. The different levels of RSC in irrigation water were prepared by dissolving required amount of NaCl, Na_2SO_4, $NaHCO_3$, $CaCl_2$ and $MgCl_2$ in base water (control) (Table 1). The normal tube well water (base water) was used for first irrigation in all plots at CRI (Crown Root Initiation) stage and later on crop was irrigated five times with varying alkali water during whole growth period as per plan of experiment. To check the lateral movement of water and salts buffer strips around each irrigation channel were kept.

The composition of the prepared waters is given in Table 1.

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Table 1 Composition of synthetic irrigation water

Residual Sodium Carbonate (RSC mmol L^{-1})	Electrical conductivity (EC dSm^{-1})	Sodium Absorption Ratio (SAR)	Ionic composition (mmol L^{-1})						
			Na^+	Ca^{2+}	Mg^{2+}	HCO_3^-	CO_3^{2-}	Cl^-	SO_4^{2-}
2.0 (Base water)	1.3	8.2	10	1.5	1.5	4.5	0.5	6.5	1.5
6.0	3.2	16.7	26.4	2.5	2.5	10.0	1.0	10.5	10.5
10.0	3.2	16.7	26.4	2.5	2.5	12.0	3.0	8.5	8.5

Result and Discussion

Yield

The results presented in Table 2 and Figure 1 for grain and straw yield of wheat decreased significantly with increase in level of RSC in irrigation water during both the years of study and also when data were pooled. Decline in crop yields due to high RSC water irrigations could be ascribed to the deteriorating effect of high pH and RSC on chemical, physical and biological soil fertility parameters along with Ca deficit in the soil solution (Choudhary *et al*. 2019). This may be explained on the basis that increasing RSC in irrigation water increased the ESP and pHs of soil resulting into decreased availability of P, K, Ca and Mg but increased the uptake of Na which is toxic to plant. The higher amount of Na may adversely affect the physiological, metabolic and enzymatic activities and utilization of photosynthates in plant. The cell elongation and cell division may also be adversely affected due to higher accumulation of Na. This causes a reduction in number of tillers and plant height (Hajiboland, *et al*. 2014; Sheoran, *et al*. 2021). In this study, also the number of tillers and plant height decreased drastically with increasing level of RSC in irrigation water. This may be a reason for decrease in grain and straw yield of wheat. Further, the reduction in grain and straw yield may also be due to the poor physical condition of soil caused by accumulation of higher amount of Na in soil. Under high RSC water increased exchangeable Na has detrimental effect on physical condition and nutritional properties, resulting in to poor root development and plant growth. This resulted in decrease in yield of wheat. Choudhary *et al*. (2019) and Sheoran, *et al*. (2021) also expressed similar views and observed reduction in the grain and straw yield with an increase in levels of RSC in water.

The significantly maximum increased in grain and straw yield of wheat was observed with the application of vermicompost @ 5 t ha^{-1} (34.62 %) and FYM @ 15 t ha^{-1} (30.71%) over control during both the years and during pooled analysis (Table 2) but the effect of vermicompost and FYM was statistically at par with each other. The improvement in yield might be due to the result of overall improvement in soil environment due to decrease in pHs and ESP under the influence of applied organic manures. These beneficial effects favoured greater availability of plant nutrients and their steady supply throughout growth for optimum development as explained earlier in preceding paragraphs and observed in the present study. The higher nutrients availability and congenial environment for their uptake, favored greater synthesis of carbohydrates and their efficient partitioning into different sinks including reproductive structures which ultimately brought significant improvement in effective tillers and grain yield. The straw yield increased due to improvement in vegetative growth of wheat. These results are in conformity with those of Bhakher *et al.,* (1997) and Kamaleshwaran and Elayaraja, (2021) who have reported increased in yield attributes (plant height and numbers of tillers) and yield of rice and wheat due to application of vermicompost and farmyard manure might have supplied the essential minerals and worked as catalyst for efficient use of applied nutrients for increasing the yield attribute. Similar results were also reported by Sharma *et al*. (2009), Abbas *et al*. (2009), Thakur *et al*. (2011), Prativa and Bhattarai (2011) and Anand *et al*. (2014), Vishram *et al*. (2014) and Choudhary *et al*. (2020) also studied on response of FYM on seed yield and quality of crop under high RSC water.

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The grain and straw yield also increased significantly with increase in levels of Fe during both the years and in pooled analysis (Table 2). The favourable influenced of applied Fe on these characters might be due to its catalytic effect on most on the physiological and metabolic process of plant. Fe is involved in the formation of chlorophyll and plays a somewhat similar role to Mg in the porphyrin structure of chlorophyl (Pushnik, *et al.* 984). Fe is also a constitute of large number of metabolically active compound like cytochromes, haeme and non-haeme enzymes and other functional metallo proteins such as ferredoxin and haemoglobin. Fe plays an important role in Zn, Cu, Mg and Mn metabolism. It is widely agreed that Fe is directly involved in protein synthesis (Clarkson and Hanson, 1980). The application of Fe in a soil deficient in its status, improved overall growth and development of plants and ultimately the effective tillers, plant height, grain and straw yield increased under irrigation with high RSC waters. The findings of present investigation are supported by Radder and Husen (2017) and Janmohammadi *et al*. (2018).

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Table 2 Effect of alkali water, organic manures and iron application on grain and straw yield (q ha^{-1}) of wheat

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Alkali water (RSC mmol L^{-1})						
W_2 (2 Base water)	35.56	34.10	34.83	56.32	54.32	55.32
W_6 (6)	32.13	31.03	31.58	48.33	46.54	47.43
W_{10} (10)	26.72	25.31	26.02	38.65	37.66	38.15
SEm±	0.55	0.47	0.36	0.84	0.63	0.53
CD (P=0.05)	1.66	1.41	1.05	2.52	1.90	1.52
Organic manures						
M_0 (Control)	26.13	24.47	25.30	39.36	37.92	38.64
M_1 (FYM @ 15 t ha^{-1})	33.69	32.44	33.07	51.67	49.65	50.66
M_2 (Vermicompost @ 5 t ha^{-1})	34.58	33.53	34.06	52.26	50.94	51.60
SEm±	0.55	0.47	0.36	0.84	0.63	0.53
CD (P=0.05)	1.66	1.41	1.05	2.52	1.90	1.52
Iron levels ($FeSO_4 .7H_2O$)						
F_0 (Control)	27.10	25.21	26.16	39.61	37.05	38.33
F_{50} (50 kg ha^{-1})	31.22	30.46	30.84	47.11	45.85	46.48
F_{100} (100 kg ha^{-1})	34.37	33.29	33.83	52.58	51.57	52.07
F_{150} (150 kg ha^{-1})	33.17	31.63	32.40	51.76	50.23	50.99
SEm±	0.72	0.71	0.51	0.80	0.82	0.57
CD (P=0.05)	2.05	2.02	1.42	2.28	2.32	1.61

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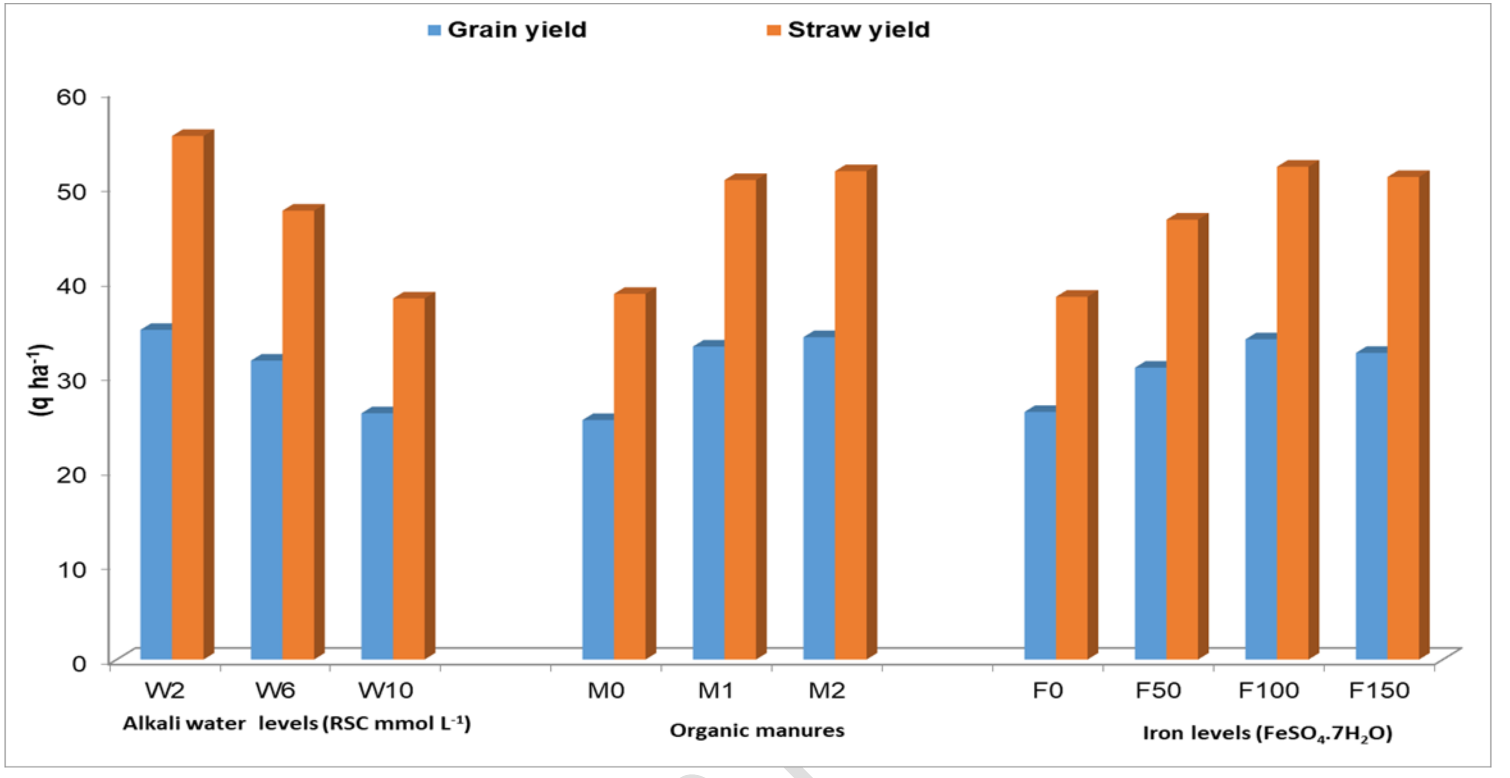

Fig. 1 Effect of alkali water, organic manures and iron on grain and straw yields of wheat

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Interactive effect of Residual Sodium Carbonate (RSC) water and organic manures on grain and straw yield

The interactive effect of RSC water and organic manures on grain and straw yield was found significant during both the years and in pooled analysis showed in Table 3 and 4 and Figure 2 and 3 and data reveal that grain and straw yield increased significantly with organic manures treatment under all the levels of RSC in water.Grain and straw yield obtained with RSC water (W_2) and 5 t ha^{-1} vermicompost (M_2) was significantly superior to the yield obtained over control and statically at par with 15 t ha^{-1} FYM along with other level of RSC water W_6 and W_{10}. The maximum grain yield was recorded under W_2 (34.83 q ha^{-1}) and minimum under W_{10} (26.02 q ha^{-1}). This indicate that harmful effect of high RSC water can be mitigated by applying organic manures result of overall improvement in soil physical environment due to decreased in pH, electrical conductivity (ECe), exchangeable sodium percentage (ESP) and increased cation exchange capacity (CEC) and reducing the accumulation of Na in soil resulting in to higher grain and straw yield under W_2 M_2 over rest of the treatment combinations. The results are in close conformity with Pareek and Yadav (2011) and Rathi *et al*. (2020).

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Table 3 Interactive effect of application of alkali water and organic manures on grain yield (q ha^{-1}) of wheat

Treatments	2019-20			
	M_0 (Control)	**M_1 (FYM @ 15 t ha^{-1})**	**M_2 (Vermicompost @ 5 t ha^{-1})**	**Mean**
W_2 (2 Base water)	31.31	37.29	38.07	35.56
W_6 (6)	27.91	34.13	34.36	32.13
W_{10} (10)	19.19	29.66	31.31	26.72
Mean	26.13	33.69	34.58	
SEm±	0.96			
CD (P=0.05)	2.88			
	2020-21			
W_2 (2 Base water)	29.64	36.05	36.62	34.10
W_6 (6)	26.24	33.03	33.81	31.03
W_{10} (10)	17.52	28.25	30.17	25.31
Mean	24.47	32.44	33.53	
SEm±	0.82			
CD (P=0.05)	2.44			
	Pooled			
W_2 (2 Base water)	30.47	36.67	37.35	33.909
W_6 (6)	27.07	33.58	34.08	30.577
W_{10} (10)	18.36	28.95	30.74	24.549
Mean	24.41	32.81	34.04	
SEm±	0.63			
CD (P=0.05)	1.82			

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Table 4 Interactive effect of application of alkali water and organic manures on straw yield (q ha^{-1}) of wheat

Treatments	2019-20			
	M_0 (Control)	M_1 (FYM @ 15 t ha^{-1})	M_2 (Vermicompost @ 5 t ha^{-1})	Mean
W_2 (2 Base water)	50.61	58.93	59.41	56.32
W_6 (6)	36.59	54.14	54.26	48.33
W_{10} (10)	30.89	41.95	43.10	38.65
Mean	39.36	51.67	52.26	
SEm±	1.46			
CD (P=0.05)	4.37			
	2020-21			
W_2 (2 Base water)	48.87	56.53	57.55	54.32
W_6 (6)	34.86	52.22	52.55	46.54
W_{10} (10)	30.04	40.21	42.73	37.66
Mean	37.92	49.65	50.94	
SEm±	1.10			
CD (P=0.05)	3.29			
	Pooled			
W_2 (2 Base water)	49.74	57.73	58.48	54.11
W_6 (6)	35.72	53.18	53.40	44.56
W_{10} (10)	30.47	41.08	42.91	36.69
Mean	40.10	49.41	50.70	
SEm±	0.91			
CD (P=0.05)	2.64			

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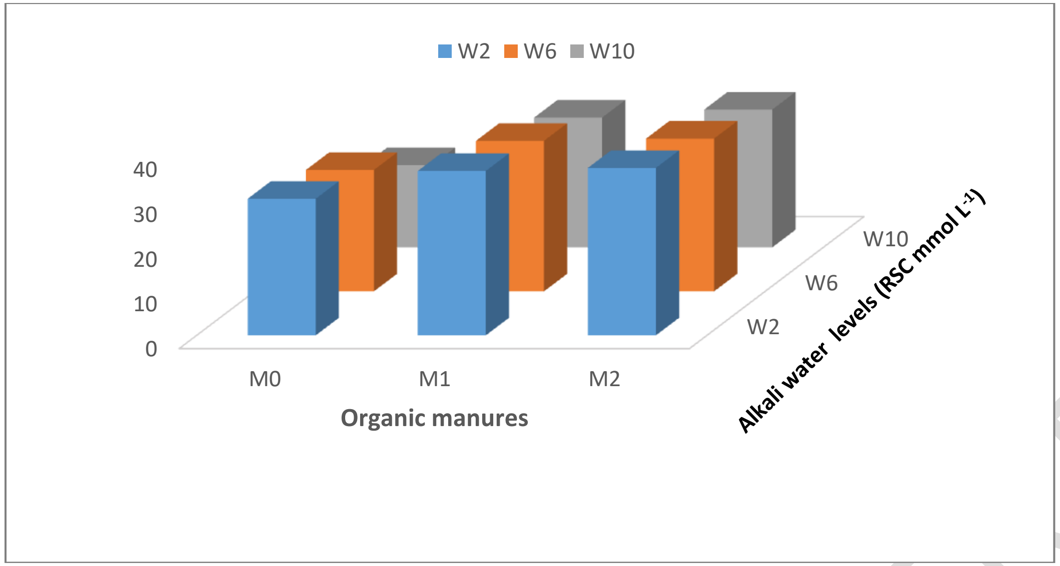

Figure 2 Interactive effect of application of alkali water and organic manures on grain yield of wheat (Pooled)

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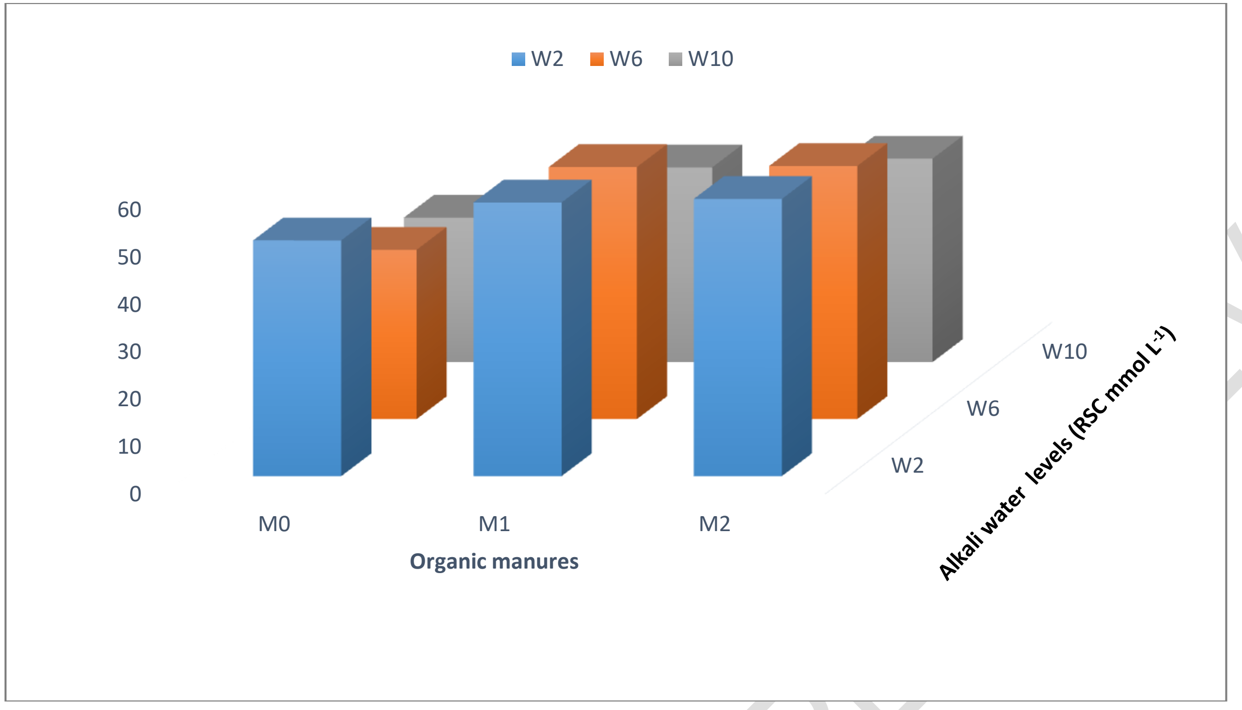

Figure 3 Interactive effect of application of alkali water and organic manures on straw yield of wheat (Pooled)

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Conclusion

Our results showed that effect of RSC water and organic manure application on grain and straw yields of wheat was found significant and maximum being with 2 mmol L^{-1} RSC water and vermicompost @ 5 t ha^{-1} treatment combination indicating the magnitude of reduction in yields (grain and straw) being less with vermicompost and FYM at all the levels of RSC water.

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