

Original Research Article

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Effect of FYM, Mulching and Agro-Chemicals on Yield, Nutrient Content and their uptake by Wheat (*Triticum aestivum* L.) under Different Sowing Dates

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ABSTRACT

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A field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during *rabi* 2016-17 to study the effect of FYM, mulching and agro-chemicals on yield, nutrient content and their uptake by wheat under different sowing dates. The experiment consisted of 12 treatment combinations comprising of two sowing dates (Timely, Late) and six management practices, viz., control, FYM, Mulching, FYM + Mulching, FYM + Mulching + ZnSO₄ and FYM + Mulching + KCl (P₀, P₁, P₂, P₃, P₄, P₅). The experiment was conducted in factorial randomized block design and replicated thrice. Results showed that timely sowing of crop had significant effect on yield attributes (effective tillers, grains ear⁻¹, ear length, grain weight ear⁻¹), yield (grain, straw and biological) and nutrient uptake (N, P and K) over control. Maximum grain yield (5461 kg ha⁻¹), straw yield (6124 kg ha⁻¹) and biological yield (11585 kg ha⁻¹) were recorded with timely sown crop, which was significantly higher over late sown crop. Result further showed that application of 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ Mulch + 0.2% KCl (P₅) recorded highest grain yield (5400 kg ha⁻¹), straw yield (6633 kg ha⁻¹) and biological yield (12033 kg ha⁻¹) followed by 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ Mulch + 0.5 % ZnSO₄ (P₄) and 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ Mulch (P₃). Also, same treatment resulted in higher nutrient content in grain and straw and their uptake.

Introduction

Wheat (*Triticum aestivum* L.) is one of the important food crops grown world-wide. It is the second most important cereal after rice in India a key crop of the green revolution and post green revolution era. It is the main staple food of nearly 35 per cent of the world

population. It provides 21 per cent of the food calories and 20 per cent protein for more than 4.5 billion people in 94 developing countries (Braun *et al.*, 2010). Further, with increased global population and change in consumption preference the demand of wheat increased substantial during the past 50 years. Globally wheat stands second in terms of total

production with a quantum of 713.97 million tonnes from 220.45 million ha area (FAS/USDA, 2014). India has the largest area under wheat (31.2 million ha), with a productivity of 3075 kg ha⁻¹ and is the second largest producer of wheat (95.9 million tonnes) after China in the world (FAOSTAT, 2017). In Rajasthan, the area and production of wheat was 3.3 million hectare and 12.43 million tonnes during 2016-17, respectively (Govt. of Rajasthan, 2016-17). The estimated food grain requirement of India by 2025 is around 300 million tonnes that has to be elevated from the current estimated production of 275 million tonnes (Government of India, 2016-17) and the share of wheat will be most important to meet the food grain requirement for future. Recent global climate change has made the situation more serious in agriculture-based enterprises. Climate change is impacting the natural ecosystems and is expected to have substantial adverse effects on productivity of various crops in India due to environmental stresses. In last few years, temperature fluctuation (variation) during wheat growing season was also observed in Rajasthan and thereby, growth and yield of timely as well as late sown wheat was adversely affected.

The impact of high temperature on wheat productivity can be minimized by adoption of various management practices. Selecting optimum planting time, avoids high temperature stress during anthesis and grain filling. High temperature at that time shortens the season and reduces yield. By adjusting sowing time crop can escapes to hot and desiccating wind during grain filling period. In addition, organic matter, residue retention, mulching, water management and foliar spray of Zn and KCl can also help in mitigating the temperature stress effects. Organic manure applications improve soil physical properties through increased soil aggregation, improves aggregate stability, decrease in the volume of

microspores while increasing macrospores, increase saturated hydraulic conductivity and water infiltration rate and improves soil water-holding capacity at both field capacity and wilting point. Several workers reported positive effect of FYM on dry matter production, yield and nutrient uptake by wheat. Organic mulches provide better soil water status and improved plant canopy in terms of biomass, root growth, leaf area index and grain yield, which subsequently resulted in higher water and nitrogen uptake and their use efficiencies and may reduce expected reduction of economic yield under adverse climate during reproductive stage of wheat (Singh *et al.*, 2011 and Chakraborty *et al.*, 2010). In recent past some encouraging results were obtained with foliar spray of agro-chemicals and various nutrients at post flowering stage on yield of wheat. Potassium plays vital role under moisture stress condition by stimulating biological process in the plant cell such as enzymes activation, respiration, photosynthesis, chlorophyll synthesis, carbohydrate formation, water balance in leaves and regulation of stomata opening as well as direct effect on the disease resistance (Mesbah, 2009). Hence, the present experiment was conducted to assess the effect of FYM, mulching and agro-chemicals on yield, nutrient content and their uptake by wheat (*Triticum aestivum* L.) under different sowing dates.

Materials and Methods

The experiment was conducted during *rabi* season 2016-17 at Instructional Farm, Rajasthan College of Agriculture, Udaipur (Rajasthan). The soil of experimental site was clay loam in texture, having slight alkaline reaction (pH 7.7). The soil was medium in available nitrogen (295.3 kg ha⁻¹) and phosphorus (18.4 kg ha⁻¹), and high in available potassium (292.7 kg ha⁻¹). The experiment comprised of twelve treatment

combinations (two sowing dates and six management practices) that were laid out in factorial randomized block design and replicated three times. The plot size was 1.8 m x 8.0 m. The wheat variety HI-1544 was sown on 10 November, 2016 and 15 December, 2016 as per treatments. A uniform seed rate of 100 kg ha⁻¹ was used at inter row spacing of 20.0 cm. In order to obtain uniform plant stand, seeds were weighed for each plot separately. Sowing was done manually in furrows followed by irrigation. Recommended dose of fertilizers, *i.e.*, 90 kg N + 60 kg P₂O₅ ha⁻¹ were applied through DAP and urea. Half of N and full dose of P were applied as a basal dose at the time of sowing.

Remaining quantity of N were applied as top dressing on standing crop through urea in two equal split doses at the time of first and second irrigation. Well rotten FYM was applied @ 10.0 t ha⁻¹ at the time of sowing as per treatments. Maize stover was applied as mulch @ 4.0 t ha⁻¹ just after sowing of the crop as per treatments. Agro-chemicals (ZnSO₄ and KCl) were weighed as per treatments and dissolved in water (600 liter ha⁻¹) and applied as per treatments. The agro-chemicals were sprayed through knapsack sprayer fitted with flat fan nozzle. Five plants were randomly selected from each plot. Number of effective tillers was manually counted on 1.0 m⁻¹ row length at harvest. Effective tillers from four randomly selected 0.5 m area were counted in each plot and average number of effective tillers 1.0 m⁻¹ was worked out. The randomly selected five ears were separately threshed and grains were counted for determining average number of grains ear⁻¹. The randomly selected five ears were separately threshed and weighed. Then average grain weight ear⁻¹ was computed. The length of five randomly selected ears from each experimental plot was measured including awns and averaged.

It was expressed in cm. A composite sample of sun-dried grains was taken from the final produce in each plot at the time of threshing. Thereafter, 1000 grains were counted, weighed and expressed in g. The crop was harvested on maturity. The plants from border area were harvested separately and removed from each plot.

The plants from net area were harvested and produce was tied in bundles and tagged. Dried bundles of individual plot were weighed to record biological yield and then threshed with power operated thresher and the produce was winnowed, cleaned and weighed separately to record grain yield plot⁻¹ and to compute yield kg ha⁻¹. The harvest index was calculated by dividing the economic yield (grain yield) by biological yield and expressed in per cent (Singh and Stoskopf 1971).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Plant sample of the crop collected at harvesting stage were first oven dried and then processed for estimation of N, P and K. Estimation of N was done by colorimetric method using Nessler's' reagent to develop colour (Snell and Snell 1949). P content was determined by Vanadomolybdo phosphoric acid yellow colour method (Richards, 1954) while K by Flame photometer method (Jackson, 1973) method. The total uptake of nitrogen, phosphorus and potassium was computed from N, P and K concentration in grain and straw at harvest stage using the following relationship:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content in seed (\%)} \times \text{Seed yield (kg/ha)} + \text{Nutrient content in straw (\%)} \times \text{Straw yield (kg/ha)}}{100}$$

Results and Discussion

Effect on yield

Sowing date

The data presented in (Table 1 and 2) show that different dates of sowing brought about significant variation on yield attributes (effective tillers, grains ear⁻¹, ear length, grain weight ear⁻¹) and yield (grain, straw and biological) over control. Timely sown crop sown recorded significantly higher yield attributes *viz.*, effective tillers m⁻¹ row length, grains ear⁻¹, ear length, grain weight ear⁻¹ and test weight over late sown crop (Table 1).

The interesting behavior exhibited by different sowing dates may be explained by the fact that early sown crop was exposed to favorable weather during complete life span and thus the different phases of plant life was completed at appropriate timings, which resulted in production of more number of effective tillers. The late sown crop could not enjoy advantages of favorable weather conditions available for the early sowing. Similar responses were also recorded by Kumar and Sharma (2003), Shirpurkar *et al.*, (2008) and Mukherjee (2012).

The timely sown crop produced ears of maximum length. It might be attributed due to the fact that when the crop was sown late, there was low temperature in the beginning but after mid-February onward the temperature started rising very fast and the plant did not get sufficient favorable environment to express their full potentiality.

Similar observations were also reported by Kumar and Sharma (2003) and Pandey *et al.*, (2010). Number of grains ear⁻¹ significantly influenced by different sowing dates and decreased delayed sowing. It was influenced by environment particularly that of

temperature prevailed during the time of sowing, vegetative and reproductive stages. In timely sown crop, the numbers of grains ear⁻¹ were more and of good weight, which positively contributed to high yield. High temperature during the later part of reproductive stages in late sowing caused forced maturity resulting in development of grains which were small, shriveled and of low weight (Table 1).

Environment particularly that of temperature prevailed during the time of reproductive phase influenced the test weight. Significant influence of date of sowing was observed on test weight and was higher in timely sown crop and decreased as sowing was delayed.

This might be due to the fact that under later sown conditions the grains were forced to mature and dry because of sudden rise in temperature coupled with low relative humidity during milking to physiological maturity. Thus, the grains obtained from late sown crop, *i.e.*, 15th December were small and shriveled and ultimately resulted in lower test weight. The results are in close agreement with findings of Dhaka *et al.*, (2006), Shirpurkar *et al.*, (2008) and Mukherjee (2012) and Amrawat *et al.*, (2014).

Maximum grain yield (5461 kg ha⁻¹), straw yield (6124 kg ha⁻¹) and biological yield (11585 kg ha⁻¹) were recorded with timely sown crop registered significant increase in grain (22.96 %), straw (14.29%) and biological (18.22 %) yields (Table 1) over late sown crop. Late sown crop (15th December) experienced higher mean temperature during reproductive phase as against the mean temperature in normal sown crop. This shortened the crop duration by 20 days compared to normal sown crop and caused force maturity, resulted in shriveled grain and ultimately low grain yield under late sown crop.

FYM, mulching and agro-chemicals

A significant variation in yield attributes and yield of wheat was observed due to various management practices (FYM, mulch alone and in combination with agro-chemicals). FYM + mulch alone and in combination with foliar spray of 0.5 % ZnSO₄ and 0.2% KCl significantly improved yield attributing characters in wheat, viz., effective tillers m⁻¹ row length, grains ear⁻¹, ear length, grain weight ear⁻¹ and test weight over control. The highest value of yield attributing characters was recorded under treatment 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch + 0.2% KCl. The reason for better performance of KCl spray in combination with FYM + mulch was owing to the fact that KCl spray helped in maintaining higher water potential, as potassium plays important role in osmoregulation and thereby it increases osmotic potential of leaves, which causes reduction in loss of water from leaves. Foliar spray of potassium fertilizer increases the photosynthates production in plant and thus increases the translocation of dry matter to the grain, which ultimately increases the total grain weight and yield (Kajla *et al.*, 2015).

Also, potassium plays vital role under moisture-stress condition by stimulating biological process in the plant cell such as enzymes activation, photosynthesis, chlorophyll synthesis, carbohydrate formation, water balance in leaves and stomata opening (Mesbah, 2009). Further, 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch + 0.5 % ZnSO₄ and 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch + 0.2% KCl also improved test weight of wheat grains (Table 1). Grain yield is a resultant of yield attributes and therefore, expression of yield attributes. Results revealed that application of 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ Mulch + 0.2% KCl (P₅) recorded highest grain yield (5400 kg ha⁻¹), straw yield (6633 kg ha⁻¹) and biological yield (12033 kg ha⁻¹)

followed by 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ Mulch + 0.5 % ZnSO₄ (P₄) and 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ Mulch (P₃). Application of 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch, 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch + 0.5 % ZnSO₄ and 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch + 0.2% KCl registered significant increase in grain yield by 11.05, 12.30 and 18.68 per cent, respectively over control (4550 kg ha⁻¹) (Table 1) over control. This could be ascribed due to overall improvement in crop growth as reflected by plant height, DMA, number of tillers m⁻¹ row length and yield bearing characters. A significant increase in straw and biological yields was observed under various management practices (Table 1). This might be due to favorable effect of FYM, mulch, FYM + mulch and foliar application of ZnSO₄ and KCl on growth and development of the crop. Regarding harvest index, no definite trend was observed with various management practices.

Effect on nutrient content and uptake

Sowing date

Nitrogen, phosphorus and potassium contents in grain and straw influenced significantly by different sowing dates. Nutrient uptake by grain and straw was also significantly affected by different sowing dates (Table 2). The higher nitrogen (115.91 kg/ha), phosphorus (28 kg/ha) and potassium (105.06 kg/ha) uptake was recorded under timely sown crop. Significant increase in nitrogen, phosphorus and potassium uptake by grain as well as total uptake of wheat under timely sown crop recorded in the present study might be due to higher nitrogen, phosphorus and potassium content in grain and straw. The positive impact of nutrient uptake in grain seems to be due to better growth of crop, as evidenced by higher dry matter accumulation, which might have maintained adequate supply of metabolites for better growth.

Table.1 Effect of FYM, mulching and agro-chemicals on yield attributes, yield and harvest index of wheat

Treatments	Yield attributes					Yield (kg ha ⁻¹)			Harvest Index (%)
	Effective tillers (Numbers m ⁻¹ row length)	Grains ear ⁻¹	Ear length (cm)	Grain weight ear ⁻¹ (g)	Test Weight (g)	Grain	Straw	Biological	
Sowing date									
D₁	95.24	49.11	13.67	2.52	49.56	5461	6124	11585	47.37
D₂	81.39	45.11	12.44	2.10	40.15	4441	5358	9799	45.33
SEm ±	1.73	0.59	0.28	0.03	0.89	91	129	134	0.82
CD (P=0.05)	5.06	1.74	0.83	0.08	2.60	266	377	394	NS
FYM, mulching and agro-chemicals									
P₀	77.80	43.50	11.83	2.13	41.54	4550	4839	9389	48.32
P₁	84.92	45.83	12.33	2.15	43.87	4783	5592	10375	46.01
P₂	86.49	46.33	12.83	2.25	43.52	4808	5717	10525	45.80
P₃	93.23	46.67	13.33	2.28	45.09	5053	5652	10705	47.51
P₄	93.60	48.67	13.50	2.43	46.05	5110	6015	11125	45.86
P₅	93.87	51.67	14.50	2.60	49.05	5400	6633	12033	44.61
SEm ±	2.99	1.03	0.49	0.05	1.53	157	223	232	1.42
CD (P=0.05)	8.77	3.01	1.44	0.14	4.50	460	653	682	NS

Note- NS- Non-significant, D₁- Timely sowing (10th November, 2016), D₂- Late sowing (15th December, 2016), P₀- Control, P₁- 10 t ha⁻¹ FYM, P₂- 4 t ha⁻¹ Mulch, P₃- 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ Mulch, P₄- 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ Mulch + 0.5% ZnSO₄, P₅- 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ Mulch + 0.2% KCl.

Table.2 Effect of FYM, mulching and agro-chemicals on nutrient content in grain and straw and their uptake by wheat

Treatments	N concentration (%)		Total N uptake (kg/ha)	P concentration (%)		Total P uptake (kg/ha)	K concentration (%)		Total K uptake (kg/ha)
	Grain	Straw		Grain	Straw		Grain	Straw	
Sowing date									
D₁	1.687	0.385	115.91	0.371	0.124	28.00	0.463	1.299	105.06
D₂	1.488	0.361	85.56	0.327	0.119	20.92	0.451	1.250	87.69
SEm ±	0.016	0.004	1.46	0.003	0.002	0.39	0.003	0.012	1.65
CD (P=0.05)	0.046	0.013	4.28	0.010	0.005	1.15	0.008	0.035	4.83
FYM, mulching and agro-chemicals									
P₀	1.521	0.355	86.88	0.316	0.116	20.04	0.426	1.213	78.21
P₁	1.563	0.366	95.62	0.339	0.118	22.89	0.445	1.232	90.40
P₂	1.567	0.364	96.72	0.346	0.118	23.46	0.454	1.250	93.70
P₃	1.592	0.373	102.07	0.352	0.122	24.89	0.463	1.286	96.34
P₄	1.635	0.389	107.32	0.367	0.125	26.43	0.464	1.299	101.58
P₅	1.648	0.393	115.81	0.376	0.128	29.06	0.489	1.379	118.04
SEm ±	0.027	0.008	2.53	0.006	0.003	0.68	0.005	0.021	2.86
CD (P=0.05)	0.080	0.022	7.41	0.017	0.008	1.98	0.014	0.061	8.37

Note- D₁- Timely sowing (10th November, 2016), D₂- Late sowing (15th December, 2016), P₀- Control, P₁- 10 t ha⁻¹ FYM, P₂- 4 t ha⁻¹ Mulch, P₃- 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ Mulch, P₄- 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ Mulch + 0.5% ZnSO₄, P₅- 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ Mulch + 0.2% KCl.

Thus, better developed root system might have facilitated in more extraction of nutrients from soil and translocation to plant parts. Higher concentration of nutrients in grain along with grain and straw yields under timely sown crop resulted in higher nutrients. The results are in close agreement with those of Chourasiya *et al.*, (2013) and Rahman *et al.*, (2013).

FYM, mulching and agro-chemicals

Nitrogen, phosphorus and potassium contents in grain and straw influenced significantly by application of 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch + 0.5 % ZnSO₄ and 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch + 0.2% KCl. Further, phosphorus and potassium contents in grain increased by application of 10 t ha⁻¹ FYM, 4.0 t ha⁻¹ mulch and 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch. Nutrient uptake by grain, straw and total was also significantly affected by application of 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch, 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch + 0.5 % ZnSO₄ and 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch + 0.2% KCl (Table 2).

Further, total uptake of nitrogen, phosphorus and potassium was significantly affected by application of 10 t ha⁻¹ FYM and 4.0 t ha⁻¹ mulch. Significant increase in nitrogen, phosphorus and potassium uptake by grain and straw as well as total uptake of wheat under treatments 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch, 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch + 0.5 % ZnSO₄ and 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch + 0.2% KCl recorded in the present study might be due to higher nitrogen, phosphorus and potassium contents in grain and straw and as well as more production of biological yield. It is well established that nutrient uptake by the crop is primarily governed by dry matter accumulation and secondly on nutrient concentration at cellular level. Thus, enhanced uptake of nitrogen, phosphorus and potassium in grain, straw and total uptake by the crop under the influence of

various management practices seems to be in accordance with overall improvement in growth, productivity and increase in nutrient concentration in plants.

On the basis of the findings of the present investigation, it can be concluded that under prevailing climatic condition of agro-climatic zone IV A of the Rajasthan timely sown wheat crop and application of treatment 10 t ha⁻¹ FYM + 4.0 t ha⁻¹ mulch + 0.2% KCl was found the most superior treatment combination for obtaining higher yield, nutrient content and their uptake by wheat over rest of the treatment.

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