

Original Research Article

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Effect of Moisture Regimes, FYM and Levels of P Carriers on Yield, Quality and P Uptake by Wheat in Loamy Sand

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ABSTRACT

In field study, total 36 treatment combinations consisting of three moisture regimes as main plot treatment and 12 combinations of two levels of FYM, three levels of P carriers as sub-plot treatments evaluated in split plot design with three replications using wheat variety GW-451 as test crop. The results revealed that the maintenance of moisture between 100 and 75 % available water content (W_1) significantly increased the length of earhead, number of grains/earhead, 1000-grain weight, grain and straw yield as well as gluten content. The treatments W_1 and W_2 resulted in 22.11 and 18.45 per cent higher grain yield as well as 23.56 and 19.91 per cent higher straw yield, respectively over W_3 treatment. Whereas, maintenance of soil moisture between 100 and 25 % AWC (W_3) resulted significantly higher P content in grain and straw of wheat. Application of phosphorus @ 90 kg P_2O_5 as MAP with 10 t/ha FYM ($P_3S_1M_1$) gave significantly higher length of earhead, number of grains/earhead, 1000-grain weight, grain yield and application of 60 kg P_2O_5 /ha as DAP with 10 t FYM/ha registering 4660 kg/ha grain yield which was at par with $P_3S_1M_1$ while, Treatment combinations $P_3S_2M_1$ showed significantly higher P content in grain and straw, but it was at par with $P_3S_1M_1$ and $P_2S_2M_1$. While significantly the highest P uptake by grain, straw and total P uptake by wheat was recorded by $P_3S_1M_1$, but it was at par with $P_2S_2M_1$. The interaction $W_2 \times P_3S_1M_1$ recorded maximum length of earhead (11.09 cm), number of grains/earhead (68), 1000-grain weight (73.18 g), grain (5210 kg/ha) and straw (11969 kg/ha) yield of wheat and gluten content (39.42 %) in grain. The lowest value for bulk density (1.61 Mg/m^3) and the highest value for maximum water holding capacity (22.49 %) of soil after harvest were recorded by $P_2S_1M_1$. Treatment combination $P_1S_2M_1$ recorded significantly higher available N (177.30 kg/ha), P_2O_5 (40.7 kg/ha) and K_2O (207.57 kg/ha) in soil after harvest.

Keywords

Moisture regimes,
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Introduction

An ideal moisture regime favors the absorption of mobile nutrients. The accessibility of immobile nutrient like PO_4^{-3} is increased due to more root development in a soil having low suction of moisture. A favorable moisture regime also, increases the uptake of available nutrients. An ideal moisture regime in combination with optimum dose of nutrient not only increases the yield,

but also the nutrient use efficiency. The extent of response to phosphorus fertilizer application in relation to moisture is determined by the rate and distance of diffusion of phosphate ion to come in contact with root surface release of non-labile phosphorus and mineralization of organic-P. Phosphate ion is partially immobile and hence, it's placement in root zone/moist layer is must for its efficient utilization. In most soils, phosphorus availability is the highest in the

surface plow layer and much lower in the sub-soil. Therefore, during a period of dry weather, if the surface soil becomes dry, plant suffers from a phosphorus deficiency even though moisture is still available in the sub-soil and plants show no water stress.

This is a potential threat to sustainable crop production. Almost 80 per cent soils in India are either low or medium in P fertility status, which reinforces the need for P application in the form of organic manures, green manures and phosphatic fertilizers to maximize the crop yields (Sanyal *et al.*, 2015). In Gujarat, 60 per cent soils are classified as deficient in available P status.

The GAU has made 38 crop specific P recommendations. Instances of erratic response to P application by different crops or crop sequences are quite common. The state average of P consumption is only 18.1 kg P₂O₅/ha (Patel *et al.*, 1994).

Wheat [*Triticum aestivum* (L.)] has been described as “king of cereals” and one of the most important staple food crop cultivated in 43 countries of the world. Wheat has its own outstanding importance as a human food; the nutritive value of wheat is fairly high as compared to other cereals. It contains 11.80, 1.50, 71.20, 1.50, 0.50, 0.32, per cent, fat, carbohydrate, mineral matter, calcium and phosphorus, respectively (Swaminathan *et al.*, 1981).

Gujarat occupies an area of 1.05 million hectares with a production of 3.13 million tonnes and productivity of 2986 kg/ha. The most important wheat growing districts of the state are Junagadh, Ahmedabad, Sabarkantha, Rajkot, Kheda, Banaskantha, Mehsana and Bhavnagar.

The combined use of moisture regimes, FYM and levels of P carriers, the immobile

properties of P can be exploited by mobilizing native plant unavailable P to available form so that, it may be recycled the native P and minimize P fertilizer particularly in wheat crop.

Materials and Methods

Climate and weather conditions

The maximum and minimum temperature ranged between 24.5 to 36.40°C and 6.8 to 18.7 °C, respectively no rainfall was received. The mean relative humidity recorded at 7.40 am ranged between 22.4 to 89.3 per cent and the mean sunshine hours ranged between 7.7 to 9.4 hours during the crop growing period.

The overall climatological data indicated that the weather conditions were observed normal and favorable for the satisfactory growth and development of the crop during the *rabi*, 2017-18.

Physico-chemical properties of soil

The representative soil sample was analyzed for different physico-chemical characteristics (Table 1).

Irrigation management

Two common irrigations were applied, first after sowing for better germination and second at 21 DAS *i.e.* crown root initiation stage of wheat crop.

After that according to treatments (moisture regimes), the irrigations were given when the moisture content in the soil was reached to 7.66, 6.60 and 5.54 per cent, which represent the availability of soil moisture at 75, 50 and 25 per cent, respectively. Periodically, the soil samples for moisture were taken up to a depth of 30 cm for determining the needs of irrigation.

Collection and preparation of plant and soil samples for chemical analysis

Plant samples

Representative plant samples were collected at the time of harvesting of crop. Grain and straw yield was recorded. The plant samples were washed with tap water followed by distilled water and dried in oven at 70°C till they attained constant weight.

The oven dried plant samples were ground in grinding mill. Finally, the powdered samples were stored in labeled polythene bags for chemical analysis than Vanadomolybdo phosphoric acid yellow colour method was used for determination of P (Jackson, 1978).

Soil samples

To assess the nutrient status of soil after harvest, a representative soil samples (0-15 cm) from three spots of each net plot after harvest of wheat crop were collected, composited and air dried in shade (Experimental details are given in table 4).

These samples were then ground using wooden mortar and pestle and passed through 2 mm sieve and were analysed for organic carbon, available N, P₂O₅, K₂O, EC, pH, bulk density and maximum water holding capacity as per standard analytical methods listed in Table 3.

Nutrient content and uptake

The concentration of the phosphorus was determined in grain and straw.

The uptake of P was computed by using the following formula.

$$\text{Phosphorus uptake (kg/ha)} = \frac{\text{Phosphorus content (\%)} \times \text{Yield (kg/ha)}}{100}$$

Results and Discussion

Yield attributes and yield

Among the levels of P carriers with and without application of FYM, combination of P₃S₁M₁ showed significantly higher length of earhead (10.02 cm), grain/earhead (61) and 1000-grain weight (65.68 g) as compared to other treatment combinations except P₂S₂M₁ which was at par with P₃S₁M₁ (Table 6). As far as interaction effect between W × PSM is concerned, W₂P₃S₁M₁ ranked at top bearing the highest length of earhead (11.09 cm), grain/earhead (68) and 1000-grain weight (73.18 g). As far as the effect of different combinations of FYM and levels of P carriers on wheat grain and straw yield was concerned (Table 6), it was observed that yield of grain with FYM and application of P @ 90 kg/ha in the form of MAP (P₃S₁M₁) was significantly higher (4708 kg/ha) over all the treatment combinations except P₂S₂M₁ (4660 kg/ha). The treatment combination P₃S₁M₁ and P₂S₂M₁ registered 47.63 and 46.13 per cent higher grain yield of wheat as compared to P₁S₂M₀. The treatment combination W₂P₃S₁M₁ showed the highest yield (5210 kg/ha). The treatment combination W₂P₃S₁M₁ yielded 85.28 per cent higher grain yield of wheat than W₂P₁S₂M₀. W₁ and W₂ treatments gave 23.56 and 19.91 per cent more straw yield of wheat as compared to W₃. Maximum straw yield (9383 kg/ha) was registered by W₁ treatment. Application of P @ 60 kg/ha in the form of DAP with FYM (P₂S₂M₁) was significantly higher straw yield (10682 kg/ha) over all the treatment combinations except P₃S₁M₁ (10532 kg/ha). The treatments P₂S₂M₁ and P₃S₁M₁ increased the straw yield of wheat to the tune of 45.83 and 43.78 per cent, respectively over P₁S₂M₀. The similar results were also observed by Singh and Agarwal (2005) with the application of FYM @ 10 and 20 t/ha and observed an increase in grain and straw yield of wheat. Shahi *et al.*, (2015) also

observed the role of P levels and FYM on wheat crop. Application of P levels significantly augmented crop growth and yield of wheat. This might be due to moisture availability for a longer period to the crop along with positive effect of moisture and FYM on P availability in soil. As far as effect of P levels and sources on wheat yield is concerned, the findings of Al Harbi *et al.*, (2013) also revealed in their studies that an application of P at a higher level in the form of DAP showed higher and significant response.

Quality parameter

The interaction effect of treatment combination $W_3P_2S_1M_0$ showed significantly lowest (20.47 %) content of gluten in wheat grain (Table 5). Although, the treatment combination $W_2P_3S_1M_1$ showed the higher gluten content (39.42%), but it was at par with the combinations $W_1P_2S_2M_1$ (35.17%) $W_2P_2S_2M_1$ (37.54 %), $W_1P_3S_1M_1$ (34.99 %), $W_2P_2S_2M_1$ (34.89 %), $W_2P_1S_1M_0$ (33.87 %) and $W_1P_3S_1M_0$ (33.43 %).

In general the combinations involving M_1 with P application at a higher level of moisture, phosphorus availability had a tendency of showing higher gluten content in wheat grains. Delay in irrigation from 70 mm to 90 mm evaporation, significantly increased wet gluten by Jazy *et al.*, (2012).

The data exhibited in Table 7 indicates that maintenance of soil moisture between 100-25 per cent, (W_3) proved its superiority over W_2 and W_1 as far as, P content in grain and straw was concerned as, it follows the Jenny's dilution effect phenomena and contained significantly higher P content in grain (0.42 %) and straw (0.31 %). Treatment combination $P_3S_2M_1$ showed significantly higher P content in wheat grain (0.52 %) and straw (0.38 %). Although, it was at par with treatment combinations $P_3S_1M_1$ and $P_2S_2M_1$.

The perusal of data given in Table 7 suggests

that phosphorus uptake by grain and straw did not differ significantly with moisture regimes. The trend of P uptake by grain and straw is in the order $W_1 > W_2 > W_3$. Different treatment combinations were found to affect the P uptake by wheat grain and straw significantly. $P_3S_1M_1$ registered higher P uptake (24.10 kg P/ha) by grain and straw (39.18 kg/ha), but it was at par with $P_2S_2M_1$ (22.60 kg/ha) in grain and (37.75 kg/ha). It seems that "dilution effect" has played a crucial role in governing the nutrient concentration in the plant parts.

Of course, content as such is deceptive yardstick for nutrient availability as it increase with decrease in the quantity of dry matter produced by a particular crop. Golakiya (1988) reported that P uptake was decreased by decreasing soil moisture level.

Nutrient status of soil after harvest

The bulk density and MWHC of soil, which is one of the important criteria of physical fertility of soil, was directly positively related with the amount of organic matter content in the soil (Table 8). Under this experimentation, this phenomenon is also true. The lowest value of BD (1.61 Mg/m^3) and highest MWHC (22.49 %) was obtained under the treatment combination $P_2S_1M_1$. Although, it was at par with $P_1S_1M_1$, $P_2S_2M_1$, $P_3S_1M_1$ and $P_3S_2M_1$. Numerically higher value under treatment combination $P_1S_1M_1$ (0.18 dS/m) was observed for electrical conductivity (EC) of soil. Treatment combinations $P_3S_1M_1$ and $P_3S_2M_1$ registered significantly the lowest soil pH (7.24) after the harvest of crop, but it was at par with $P_2S_2M_0$ (7.30), $P_2S_1M_1$ (7.30), $P_1S_2M_1$ (7.30) and $P_1S_1M_1$ (7.33). With respect to organic carbon content in soil after one season of experimentation treatment combination $P_3S_1M_1$ registered significantly higher organic carbon content (0.37 %) over other combinations (Table 8).

Table.1 Initial physico-chemical properties of the surface soil (0-15 cm) of the experimental plot before sowing of wheat crop	
Properties	Values
A. Mechanical composition	
Coarse sand (%)	44.76
Fine sand (%)	40.18
Silt (%)	7.90
Clay (%)	7.16
Textural class	Loamy sand
Taxonomy	<i>Typics Ustipsammets</i>
Depth (cm)	30
B. Physical properties	
Bulk density (Mg m ⁻³)	1.65
Infiltration rate (cm/hr)	14.8
F.C. (%)	8.72
P.W.P. (%)	4.48
A.W.C. (%)	4.24
M.W.H.C. (%)	22.12
C. Chemical properties	
pH (1 : 2 : 5) at 25 °C	7.5
EC (1 : 2 : 5) dSm ⁻¹ at 25 °C	0.18
Exchangeable Ca (meq/100 g)	5.6
Exchangeable Mg (meq/100 g)	0.8
CEC (meq/100 g)	7.48
Organic carbon (%)	0.349
Available N (kg/ha)	148.0
Available P ₂ O ₅ (kg/ha)	33.15
Available K ₂ O (kg/ha)	177.26

Table.2 Total treatment combinations

Treatments	Combinations	Treatments	Combinations
T ₁	W ₁ P ₁ S ₁ M ₀	T ₁₉	W ₂ P ₂ S ₂ M ₀
T ₂	W ₁ P ₁ S ₁ M ₁	T ₂₀	W ₂ P ₂ S ₂ M ₁
T ₃	W ₁ P ₁ S ₂ M ₀	T ₂₁	W ₂ P ₃ S ₁ M ₀
T ₄	W ₁ P ₁ S ₂ M ₁	T ₂₂	W ₂ P ₃ S ₁ M ₁
T ₅	W ₁ P ₂ S ₁ M ₀	T ₂₃	W ₂ P ₃ S ₂ M ₀
T ₆	W ₁ P ₂ S ₁ M ₁	T ₂₄	W ₂ P ₃ S ₂ M ₁
T ₇	W ₁ P ₂ S ₂ M ₀	T ₂₅	W ₃ P ₁ S ₁ M ₀
T ₈	W ₁ P ₂ S ₂ M ₁	T ₂₆	W ₃ P ₁ S ₁ M ₁
T ₉	W ₁ P ₃ S ₁ M ₀	T ₂₇	W ₃ P ₁ S ₂ M ₀
T ₁₀	W ₁ P ₃ S ₁ M ₁	T ₂₈	W ₃ P ₁ S ₂ M ₁
T ₁₁	W ₁ P ₃ S ₂ M ₀	T ₂₉	W ₃ P ₂ S ₁ M ₀
T ₁₂	W ₁ P ₃ S ₂ M ₁	T ₃₀	W ₃ P ₂ S ₁ M ₁
T ₁₃	W ₂ P ₁ S ₁ M ₀	T ₃₁	W ₃ P ₂ S ₂ M ₀
T ₁₄	W ₂ P ₁ S ₁ M ₁	T ₃₂	W ₃ P ₂ S ₂ M ₁
T ₁₅	W ₂ P ₁ S ₂ M ₀	T ₃₃	W ₃ P ₃ S ₁ M ₀
T ₁₆	W ₂ P ₁ S ₂ M ₁	T ₃₄	W ₃ P ₃ S ₁ M ₁
T ₁₇	W ₂ P ₂ S ₁ M ₀	T ₃₅	W ₃ P ₃ S ₂ M ₀
T ₁₈	W ₂ P ₂ S ₁ M ₁	T ₃₆	W ₃ P ₃ S ₂ M ₁

Table.3 Methods followed for soil analysis

Sr. No.	Element	Methods	Reference(s)
1	Organic carbon	Walkley and Black titration	Jackson (1978).
2	Available N	Alkaline KMnO ₄ method	(Subbiah and Asija, 1956).
3	Available P ₂ O ₅	Extraction: 0.5 M NaHCO ₃ (pH 7.0)	Olsen's <i>et al.</i> , (1954).
4	Available K ₂ O	Flame photometric method NH ₄ OAC (pH 7.0)	Jackson (1973).
5	Soil reaction (pH)	1 : 2.5 on Beckmen pH meter	(Jackson, 1973).
6	Electrical Conductivity (EC)	1 : 2.5 with water	(Jackson, 1973).
7	Bulk Density (BD)	Core method	(Culley, 1993).
8	Water Holding Capacity (WHC)	Gravimetric method	(Piper, 1966).

Table.4 Experimental details

A			
Main plot treatment : 03			
W ₁	=	Maintenance of moisture between 100 and 75 % availability at 0-30 cm depth	
W ₂	=	Maintenance of moisture between 100 and 50 % availability at 0-30 cm depth	
W ₃	=	Maintenance of moisture between 100 and 25 % availability at 0-30 cm depth	
B			
Sub-plot treatments :			
a. Levels of P : 03			
P ₁	=	30 kg P ₂ O ₅ /ha	
P ₂	=	60 kg P ₂ O ₅ /ha	
P ₃	=	90 kg P ₂ O ₅ /ha	
b. Sources of P : 02			
S ₁	=	MAP	
S ₂	=	DAP	
c. FYM : 02			
M ₀	=	0 t/ha	
M ₁	=	10 t/ha	

Table.5 Effect of moisture regime and combinations of FYM and levels of P carriers on gluten content in wheat grain at harvest

Treatments	Gluten content (%)		
	W ₁	W ₂	W ₃
P ₁ S ₁ M ₀	27.18	33.87	23.49
P ₁ S ₁ M ₁	28.24	31.57	29.16
P ₁ S ₂ M ₀	27.73	21.26	23.35
P ₁ S ₂ M ₁	30.76	34.89	27.04
P ₂ S ₁ M ₀	30.32	26.24	20.47
P ₂ S ₁ M ₁	30.52	26.53	25.10
P ₂ S ₂ M ₀	29.46	29.22	23.61
P ₂ S ₂ M ₁	35.17	37.54	33.04
P ₃ S ₁ M ₀	33.43	29.51	21.72
P ₃ S ₁ M ₁	34.99	39.42	32.09
P ₃ S ₂ M ₀	32.21	24.20	21.39
P ₃ S ₂ M ₁	31.84	27.28	24.26
		S.Em. ±	C.D. at 5 %
W		0.906	3.55
Treatment combination (TC)		1.205	3.40
W × TC		2.087	5.89

Table.6 Effect of moisture regime and combinations of FYM and levels of P carriers on length of ear head, number of grains/earhead, 1000-grain weight, grain yield and straw yield of wheat at harvest

Treat.	Length of ear head (cm)			Number of grains/earhead			1000-grain weight (g)			Grain yield (kg/ha)			Straw yield (kg/ha)		
	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃
P₁S₁M₀	7.65	9.53	6.62	47	58	40	50.50	61.35	43.70	3596	4481	3111	8219	10241	7151
P₁S₁M₁	7.94	8.89	8.21	38	54	50	52.50	58.56	54.23	3735	4170	3861	8488	9528	8778
P₁S₂M₀	7.82	5.98	6.57	48	36	40	51.57	39.50	43.35	3670	2812	3087	8432	6457	7087
P₁S₂M₁	8.66	9.81	7.62	53	60	46	57.90	64.72	50.28	4071	4608	3580	9259	10537	8151
P₂S₁M₀	8.53	7.37	5.76	52	44	35	56.37	48.59	38.12	4012	3463	2709	9170	7920	6225
P₂S₁M₁	8.59	7.46	7.07	53	45	43	56.66	49.24	46.68	4040	3506	3324	9235	7969	7596
P₂S₂M₀	8.28	8.22	6.65	50	50	40	54.76	54.23	43.92	3898	3861	3127	8923	8787	7127
P₂S₂M₁	9.90	10.64	9.29	60	64	57	65.31	69.52	61.35	4654	4957	4367	10626	11395	10024
P₃S₁M₀	9.38	8.31	6.12	58	51	37	62.11	54.81	40.40	4426	3901	2876	10124	8926	6605
P₃S₁M₁	9.91	11.09	9.05	60	68	55	64.19	73.18	59.68	4664	5210	4250	10661	11969	8966
P₃S₂M₀	9.07	6.80	6.03	55	41	37	59.88	44.90	39.78	4262	3198	2833	9780	7306	6475
P₃S₂M₁	8.97	7.67	6.82	55	47	41	57.77	50.62	45.05	4216	3605	3207	9682	8234	6948
-	S.Em.±	CD5%	CD5%	S.Em.±	CD5%	CD5%	-	S.Em.±	CD5%	-	S.Em.±	CD5%	-	S.Em.±	CD5%
W	0.247	0.97	W	1.310	5.14	W	1.628	6.38	W	117.927	462.96	W	297.516	1168	
TC	0.342	0.96	TC	2.201	6.21	TC	2.283	6.44	TC	159.798	451.29	TC	374.309	1057.11	
W×TC	0.592	1.67	W×TC	3.812	10.77	W×TC	3.954	11.16	W×TC	276.778	781.67	W×TC	648.321	1830.97	

*TC- Treatment combination

Table.7 Effect of moisture regime and combinations of FYM and levels of P carriers on P content in grain and straw, P uptake in grain and straw and total uptake of P by wheat at harvest

Treat.	P content in grain (%)			P uptake in grain (kg/ha)			P content in straw (%)			P uptake in straw (kg/ha)			Total uptake of P (kg/ha)		
	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃
P₁S₁M₀	0.24	0.25	0.27	8.49	11.13	8.49	0.17	0.18	0.20	14.14	18.51	14.22	22.63	29.64	22.70
P₁S₁M₁	0.28	0.26	0.31	10.37	10.66	11.75	0.21	0.19	0.22	17.19	17.75	19.47	27.56	28.40	31.22
P₁S₂M₀	0.27	0.27	0.27	9.73	7.40	8.20	0.20	0.19	0.19	16.29	12.38	13.72	26.02	19.78	21.92
P₁S₂M₁	0.28	0.28	0.30	11.24	13.01	10.65	0.20	0.21	0.22	18.64	21.69	17.66	29.87	34.71	28.30
P₂S₁M₀	0.37	0.36	0.42	14.99	12.33	11.35	0.27	0.26	0.30	24.96	20.56	19.00	39.96	32.89	30.36
P₂S₁M₁	0.45	0.45	0.49	17.94	15.88	16.39	0.33	0.33	0.36	29.90	26.30	27.29	47.84	42.17	43.67
P₂S₂M₀	0.40	0.38	0.47	15.96	14.86	14.85	0.29	0.28	0.35	26.64	24.65	24.66	42.60	39.51	39.51
P₂S₂M₁	0.48	0.47	0.51	22.47	23.24	22.09	0.35	0.34	0.37	37.38	38.93	36.96	59.84	62.17	59.05
P₃S₁M₀	0.44	0.47	0.45	19.48	18.40	12.93	0.32	0.34	0.33	32.46	30.68	21.63	51.95	49.09	34.55
P₃S₁M₁	0.49	0.52	0.53	22.64	27.25	22.41	0.35	0.38	0.39	37.71	45.61	34.22	60.35	72.86	56.63
P₃S₂M₀	0.44	0.44	0.49	18.74	13.86	13.84	0.32	0.32	0.36	31.33	23.09	23.05	50.07	36.95	36.90
P₃S₂M₁	0.49	0.53	0.53	20.62	18.92	17.05	0.36	0.38	0.39	34.51	31.49	26.97	55.14	50.40	44.02
-	S.Em.±	CD5%	CD5%	S.Em.±	CD5%	-	S.Em.±	CD5%	-	S.Em.±	CD5%	-	S.Em.±	CD5%	
W	0.005	0.021	W	0.608	NS	W	0.003	0.013	W	1.070	NS	W	1.669	NS	
TC	0.012	0.035	TC	0.831	2.34	TC	0.009	0.025	TC	1.408	3.97	TC	2.225	6.28	
W×TC	0.022	NS	W×TC	1.439	NS	W×TC	0.016	NS	W×TC	2.440	NS	W×TC	3.853	NS	

Table.8 Effect of moisture regime and combinations of FYM and levels of P carriers on BD, MWHC, EC (1: 2.5), pH (1: 2.5) and organic carbon of soil after harvest of wheat

Treat.	BD (Mg/m ³)			MWHC (%)			EC (dS/m)			pH			Organic carbon (%)		
	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃
P ₁ S ₁ M ₀	1.66	1.66	1.67	21.94	21.76	21.89	0.17	0.17	0.16	7.60	7.53	7.57	0.35	0.35	0.34
P ₁ S ₁ M ₁	1.63	1.62	1.63	22.39	22.34	22.43	0.19	0.17	0.17	7.33	7.23	7.43	0.36	0.37	0.37
P ₁ S ₂ M ₀	1.67	1.67	1.67	21.85	21.89	21.89	0.16	0.16	0.16	7.57	7.60	7.70	0.35	0.34	0.35
P ₁ S ₂ M ₁	1.62	1.63	1.63	22.48	22.43	22.43	0.17	0.18	0.18	7.30	7.37	7.23	0.36	0.36	0.36
P ₂ S ₁ M ₀	1.67	1.67	1.67	22.09	21.72	21.62	0.17	0.16	0.16	7.50	7.67	7.57	0.35	0.35	0.35
P ₂ S ₁ M ₁	1.62	1.61	1.61	22.46	22.48	22.52	0.16	0.18	0.15	7.23	7.33	7.33	0.36	0.36	0.37
P ₂ S ₂ M ₀	1.66	1.67	1.66	22.09	21.76	21.94	0.17	0.16	0.16	7.67	7.60	7.50	0.34	0.34	0.35
P ₂ S ₂ M ₁	1.62	1.62	1.63	22.39	22.52	22.34	0.17	0.18	0.17	7.27	7.27	7.37	0.36	0.36	0.36
P ₃ S ₁ M ₀	1.67	1.67	1.67	21.81	21.89	21.71	0.16	0.16	0.17	7.50	7.57	7.57	0.34	0.34	0.35
P ₃ S ₁ M ₁	1.62	1.63	1.61	22.43	22.14	22.43	0.18	0.16	0.17	7.23	7.17	7.33	0.37	0.36	0.36
P ₃ S ₂ M ₀	1.66	1.66	1.67	21.72	21.90	21.67	0.16	0.17	0.17	7.60	7.57	7.60	0.34	0.34	0.34
P ₃ S ₂ M ₁	1.61	1.63	1.61	22.34	22.39	22.48	0.17	0.17	0.17	7.27	7.27	7.20	0.36	0.36	0.37
-	S.Em.±	CD5%	CD5%	S.Em.±	CD5%	CD5%	-	S.Em.±	CD5%	CD5%	-	S.Em.±	CD5%	CD5%	CD5%
W	0.003	NS	W	0.056	NS	W	0.003	NS	W	0.041	NS	W	0.001	NS	NS
TC	0.006	0.018	TC	0.089	0.25	TC	0.008	NS	TC	0.053	0.14	TC	0.002	0.007	0.007
W×TC	0.011	NS	W×TC	0.154	NS	W×TC	0.014	NS	W×TC	0.091	NS	W×TC	0.004	NS	NS

Table.9 Effect of moisture regime and combinations of FYM and levels of P carriers on available N, available P₂O₅ and available K₂O of soil after harvest of wheat

Treat.	Available nitrogen (kg/ha)			Available P ₂ O ₅ (kg/ha)			Available K ₂ O (kg/ha)		
	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃	W ₁	W ₂	W ₃
P₁S₁M₀	129.22	134.91	148.56	29.66	30.97	34.10	151.28	157.95	173.93
P₁S₁M₁	154.34	140.90	166.68	35.43	32.34	38.26	180.69	164.95	195.14
P₁S₂M₀	146.09	145.21	145.31	33.54	33.33	33.36	171.04	170.00	170.12
P₁S₂M₁	166.32	202.56	163.01	38.18	46.50	37.42	194.72	237.15	190.84
P₂S₁M₀	137.70	151.47	155.60	31.61	34.77	35.72	161.21	177.33	182.17
P₂S₁M₁	161.61	154.04	167.67	37.10	35.36	38.49	189.21	180.34	196.30
P₂S₂M₀	149.45	159.61	159.74	34.31	36.64	36.67	174.96	186.86	187.02
P₂S₂M₁	158.57	165.32	169.83	36.40	37.95	38.99	185.64	193.54	198.83
P₃S₁M₀	137.13	168.06	163.05	31.48	35.58	37.12	160.55	196.76	190.89
P₃S₁M₁	163.21	167.23	163.63	37.47	38.39	38.71	191.08	195.79	197.42
P₃S₂M₀	151.49	174.03	175.34	34.78	39.95	40.25	177.36	203.75	205.27
P₃S₂M₁	171.11	175.99	175.93	39.28	40.40	40.39	200.33	206.04	205.97
-		S.Em.±	CD5%	CD5%	S.Em.±	CD5%	-	S.Em.±	CD5%
W		3.138	NS	W	0.724	NS	W	3.674	NS
TC		5.595	15.80	TC	1.284	3.62	TC	6.550	18.50
W×TC		9.691	NS	W×TC	2.224	NS	W×TC	11.346	NS

It is obvious that treatment receiving FYM as an organic source, showed the positive effect. Singh *et al.*, (2007) noted that such type of beneficial effect on physical fertility due to addition of organic matter due to creation of environment conducive for formation of humic acids. Stimulated the activity of soil microorganisms favours the organic carbon and reduction in bulk density. The bulk density is decreasing this could be attributed to mixing of the low density material (FYM) with the dense mineral fraction of soil (Bajpai *et al.*, 2006).

The perusal of data with respect to available N and available K₂O content in soil after harvest of wheat show that combination P₁S₂M₁ resulted in the highest available N (177.30 kg/ha) and available K₂O (207.57 kg/ha) in soil after harvest of wheat, but it was statistically at par with combinations P₃S₂M₁, P₃S₂M₀, P₃S₁M₁ and P₂S₂M₁ (Table 9). Whereas, treatment combination P₁S₁M₁ proved its superiority through registering higher value of available P₂O₅ (40.70 kg/ha). Numerically, maximum value of available N (202.56 kg/ha), available P₂O₅ (46.50 kg/ha) and available K₂O (237.15 kg/ha) in soil after harvest under W₂P₁S₂M₁ *i.e.* application of P @ 30 kg/ha as DAP and FYM @ 10 t/ha with 100-50 per cent available water (Table 9).

In the loamy sand (*Typic Ustipsamments*) of North Gujarat, maintenance of moisture regimes at 100-50 per cent available water capacity and an application of FYM @ 10 t/ha along with 60 kg P₂O₅/ha through DAP apart from recommended dose of 120 kg N/ha was found more advantageous in terms of yield, gluten content, P uptake by wheat and soil fertility status.

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