

## Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com



E-ISSN: 2278-4136 P-ISSN: 2349-8234 JPP 2019; 8(4): 1733-1736 Received: 01-05-2019 Accepted: 03-06-2019

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## Effect of moisture regimes, FYM and levels of P carriers on available P status of loamy sand in laboratory condition

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## Abstract

Incubation study was carried out during 2017, in the Laboratory of Department of Agricultural Chemistry and Soil Science, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar. 180 treatments comprising of three levels of moisture regimes ( $W_1 = 100\%$ ,  $W_2 = 50\%$  and  $W_3 = 25\%$ available water capacity), three levels P ( $P_0 = 0.0$ ,  $P_1 = 1.34$  and  $P_2 = 2.68$  mg P/100 g soil) of two P carriers (S<sub>1</sub> = MAP and S<sub>2</sub> = DAP), two levels of FYM ( $M_0 = 0$  and  $M_1 = 10$  t/ha) and five incubation intervals ( $I_0 = 01$ ,  $I_1 = 03$ ,  $I_3 = 05$ ,  $I_4 = 07$  and  $I_5 = 14$  days) were evaluated under completely randomized design (with factorial concept) with three replications. The results revealed that available P<sub>2</sub>O<sub>5</sub> content in soil was significantly increased with maintaining moisture up to 25 per cent available water capacity. Application of FYM @ 10 t/ha significantly increased the available P<sub>2</sub>O<sub>5</sub> content in soil. The phosphorus availability in soil was significantly increased with increasing the rate of P application. DAP was found superior over MAP with respect to phosphorus availability in soil. Phosphorus availability in soil was increased with increasing the incubation intervals from 01 to 14 days, but it was found highest after three days interval. It is concluded that, available phosphorus content in soil was increased significantly with maintaining available water capacity up to 25 per cent of field capacity, levels of FYM and P carriers with increase in the incubation time up to 14 days. Among the P carriers tried, DAP was found superior to MAP with respect to phosphorus availability in loamy sand.

Keywords: Moisture regimes, P carriers and incubation intervals

## Introduction

Water and the thirteen mineral nutrients generally regarded as essential for higher plants are complexly intertwined in their effects on growth and reproduction. All are essential, and yet, so interdependent that one cannot be considered without the others during their transport from the soil to the roots, absorption by roots and translocation into the plant.

Availability of water in an optimum amount is of great significance to the plant's need for and ability to absorb nutrients, and the soil's ability to supply them. The deficiency of water in the soil results in reduced tissue hydration, which retards the enzymatic reactions, closes or partially closes the stomata, decreases the cell expansion and reduces the leaf area. The reduction in leaf area is normally the major determinant of crop growth.

Organic acid anions have a role in solubilisation of mineral nutrients in the rhizosphere. Typical carboxylates (organic acid anion) released from roots of plant species include citrate, malate, malonate, acetate, fumarate, succinate and oxalate. Organic acids can also act as metal chelators in the rhizosphere, but are thought to have more important effects on phosphorus availability than on micronutrient availability (Dakora and Phillips, 2002) <sup>[2]</sup>. The role of four organic acids (lactic, formic, citric and malic) on the mobilization of native phosphorus in plant available form was assessed by Gharu and Tarafdar (2004) <sup>[5]</sup>. As on today, phosphorus is one of the nutrients that are receiving greater attention from all corners. The use of phosphorus in agriculture is very well debated today not only in terms of its nutrition value to plant, but also for the need and economics.

## Material and Methods

## Physico-chemical properties of soil

The representative soil sample was analyzed for different physico-chemical characteristics (Table 1). The soil was loamy sand in texture. The soil was low in organic carbon, available nitrogen and potassium, medium in available phosphorus.

 
 Table 1: Initial physico-chemical properties of the soil (0-15 cm) of the experimental plot Incubation study

Properties	Values
EC (1 : 2 : 5) dS m <sup>-1</sup> at 25 °C	0.18
pH (1 : 2 : 5) at 25 °C	7.5
Organic carbon (%)	0.449
Available N (kg/ha)	148.0
Available P2O5 (kg/ha)	33.15
Available K <sub>2</sub> O (kg/ha)	177.26
Bulk density (Mg/m <sup>3</sup> )	1.65
M.W.H.C. (%)	22.12

## **Experimental details**

Incubation study was carried out in the Department of Agricultural Chemistry and Soil Science, C. P. College of Agriculture, S. D. Agricultural Sardarkrushinagar during 2017. Five hundred gram of soil was taken and required quantity of FYM was added as per treatment followed by solution of P representing each source was added in each set of respective treatment to give desired concentration of P. The sample was then transferred to 1000 ml capacity plastic beaker and the desired moisture regime was brought. After adjustment of moisture regime, the weight of each beaker was recorded for maintaining the moisture throughout the incubation period. The moisture was maintained by adding the amount of water every alternate day equivalent to the loss in weight. A known amount of sample was withdrawn from each treatment at stipulated intervals. Simultaneously, the sample was also withdrawn for determination of moisture. The sample was taken as per the interval for the determination of available P<sub>2</sub>O<sub>5</sub> content in soil.

## Details of incubation study

A. Moisture regimes: 03

- $W_1 = 100\%$  Available water capacity
- $W_2 = 50\%$  Available water capacity

 $W_3 = 25\%$  Available water capacity

## B. Levels of P: 03

 $\begin{array}{l} P_0 = 0.00 \mbox{ mg P}/100 \mbox{ g soil} \\ P_1 = 1.34 \mbox{ mg P}/100 \mbox{ g soil} \\ P_2 = 2.68 \mbox{ mg P}/100 \mbox{ g soil} \end{array}$ 

## C. Sources of P: 02

- $S_1 = MAP$
- $S_2 = DAP$

## D. FYM: 02

 $\begin{array}{l} M_0 = 0 \ t/ha \\ M_1 = 10 \ t/ha \end{array}$ 

## E. Incubation intervals: 05

$$\begin{split} I_0 &= 01 \text{ day} \\ I_1 &= 03 \text{ day} \\ I_2 &= 05 \text{ day} \\ I_3 &= 07 \text{ day} \end{split}$$

 $I_4 = 14 \ days$ 

Design: CRD (With Factorial Concept) Number of repetitions: 03 Number of treatment combinations: 36 Total number of experimental beakers or units: 540

Treatment combinations

		1		1				1	
T <sub>1</sub>	$M_0W_1S_1P_0I_0$	T <sub>37</sub>	$M_0W_1S_1P_0I_1$	T <sub>73</sub>	$M_0W_1S_1P_0I_2$	T <sub>109</sub>	$M_0W_1S_1P_0I_3$	T <sub>145</sub>	$M_0W_1S_1P_0I_4$
T <sub>2</sub>	$M_0W_2S_1P_0I_0$	T <sub>38</sub>	$M_0W_2S_1P_0I_1$	T74	$M_0W_2S_1P_0I_2$	T <sub>110</sub>	$M_0W_2S_1P_0I_3$	T146	$M_0W_2S_1P_0I_4$
T3	$M_0W_3S_1P_0I_0$	T39	$M_0W_3S_1P_0I_1$	T75	$M_0W_3S_1P_0I_2$	T <sub>111</sub>	$M_0W_3S_1P_0I_3$	T147	$M_0W_3S_1P_0I_4$
$T_4$	$M_0W_1S_2P_0I_0$	T40	$M_0W_1S_2P_0I_1$	T76	$M_0W_1S_2P_0I_2$	T112	$M_0W_1S_2P_0I_3$	T148	$M_0W_1S_2P_0I_4$
T5	$M_0W_2S_2P_0I_0$	T41	$M_0W_2S_2P_0I_1$	T77	$M_0W_2S_2P_0I_2$	T113	$M_0W_2S_2P_0I_3$	T149	$M_0W_2S_2P_0I_4$
$T_6$	$M_0W_3S_2P_0I_0$	T <sub>42</sub>	$M_0W_3S_2P_0I_1$	T <sub>78</sub>	$M_0W_3S_2P_0I_2$	T <sub>114</sub>	$M_0W_3S_2P_0I_3$	T <sub>150</sub>	$M_0W_3S_2P_0I_4$
<b>T</b> <sub>7</sub>	$M_0W_1S_1P_1I_0$	T43	$M_0W_1S_1P_1I_1$	T79	$M_0W_1S_1P_1I_2$	T115	$M_0W_1S_1P_1I_3$	T <sub>151</sub>	$M_0W_1S_1P_1I_4$
<b>T</b> <sub>8</sub>	$M_0W_2S_1P_1I_0$	T44	$M_0W_2S_1P_1I_1$	T <sub>80</sub>	$M_0W_2S_1P_1I_2$	T116	$M_0W_2S_1P_1I_3$	T152	$M_0W_2S_1P_1I_4$
T9	$M_0W_3S_1P_1I_0$	T45	$M_0W_3S_1P_1I_1$	T <sub>81</sub>	$M_0W_3S_1P_1I_2$	T117	$M_0W_3S_1P_1I_3$	T153	$M_0W_3S_1P_1I_4$
T <sub>10</sub>	$M_0W_1S_2P_1I_0$	T46	$M_0W_1S_2P_1I_1$	T <sub>82</sub>	$M_0W_1S_2P_1I_2$	T118	$M_0W_1S_2P_1I_3$	T154	$M_0W_1S_2P_1I_4$
T <sub>11</sub>	$M_0W_2S_2P_1I_0$	T <sub>47</sub>	$M_0W_2S_2P_1I_1$	T <sub>83</sub>	$M_0W_2S_2P_1I_2$	T <sub>119</sub>	$M_0W_2S_2P_1I_3$	T <sub>155</sub>	$M_0W_2S_2P_1I_4$
T <sub>12</sub>	$M_0W_3S_2P_1I_0$	T48	$M_0W_3S_2P_1I_1$	T <sub>84</sub>	$M_0W_3S_2P_1I_2$	T <sub>120</sub>	$M_0W_3S_2P_1I_3$	T156	$M_0W_3S_2P_1I_4$
T <sub>13</sub>	$M_0W_1S_1P_2I_0$	T49	$M_0W_1S_1P_2I_1$	T85	$M_0W_1S_1P_2I_2$	T <sub>121</sub>	$M_0W_1S_1P_2I_3$	T157	$M_0W_1S_1P_2I_4$
T <sub>14</sub>	$M_0W_2S_1P_2I_0$	T50	$M_0W_2S_1P_2I_1$	T <sub>86</sub>	$M_0W_2S_1P_2I_2$	T <sub>122</sub>	$M_0W_2S_1P_2I_3$	T158	$M_0W_2S_1P_2I_4$
T15	$M_0W_3S_1P_2I_0$	T51	$M_0W_3S_1P_2I_1$	T87	$M_0W_3S_1P_2I_2$	T <sub>123</sub>	$M_0W_3S_1P_2I_3$	T159	$M_0W_3S_1P_2I_4$
T <sub>16</sub>	$M_0W_1S_2P_2I_0$	T <sub>52</sub>	$M_0W_1S_2P_2I_1$	T <sub>88</sub>	$M_0W_1S_2P_2I_2$	T <sub>124</sub>	$M_0W_1S_2P_2I_3$	T <sub>160</sub>	$M_0W_1S_2P_2I_4$
T17	$M_0W_2S_2P_2I_0$	T53	$M_0W_2S_2P_2I_1$	T89	$M_0W_2S_2P_2I_2$	T <sub>125</sub>	$M_0W_2S_2P_2I_3$	T <sub>161</sub>	$M_0W_2S_2P_2I_4$
T <sub>18</sub>	$M_0W_3S_2P_2I_0$	T <sub>54</sub>	$M_0W_3S_2P_2I_1$	T <sub>90</sub>	$M_0W_3S_2P_2I_2$	T <sub>126</sub>	$M_0W_3S_2P_2I_3$	T <sub>162</sub>	$M_0W_3S_2P_2I_4$
T19	$M_1W_1S_1P_0I_0$	T55	$M_1W_1S_1P_0I_1$	T91	$M_1W_1S_1P_0I_2$	T <sub>127</sub>	$M_1W_1S_1P_0I_3$	T <sub>163</sub>	$M_1W_1S_1P_0I_4$
T <sub>20</sub>	$M_1W_2S_1P_0I_0$	T56	$M_1W_2S_1P_0I_1$	T92	$M_1W_2S_1P_0I_2$	T <sub>128</sub>	$M_1W_2S_1P_0I_3$	T <sub>164</sub>	$M_1W_2S_1P_0I_4$
T <sub>21</sub>	$M_1W_3S_1P_0I_0$	T57	$M_1W_3S_1P_0I_1$	T93	$M_1W_3S_1P_0I_2$	T <sub>129</sub>	$M_1W_3S_1P_0I_3$	T <sub>165</sub>	$M_1W_3S_1P_0I_4$
T <sub>22</sub>	$M_1W_1S_2P_0I_0$	T58	$M_1W_1S_2P_0I_1$	T94	$M_1W_1S_2P_0I_2$	T <sub>130</sub>	$M_1W_1S_2P_0I_3$	T <sub>166</sub>	$M_1W_1S_2P_0I_4$
T <sub>23</sub>	$M_1W_2S_2P_0I_0$	T <sub>59</sub>	$M_1W_2S_2P_0I_1$	T <sub>95</sub>	$M_1W_2S_2P_0I_2$	T <sub>131</sub>	$M_1W_2S_2P_0I_3$	T <sub>167</sub>	$M_1W_2S_2P_0I_4$
T <sub>24</sub>	$M_1W_3S_2P_0I_0$	T <sub>60</sub>	$M_1W_3S_2P_0I_1$	T96	$M_1W_3S_2P_0I_2$	T <sub>132</sub>	$M_1W_3S_2P_0I_3$	T <sub>168</sub>	$M_1W_3S_2P_0I_4$
T <sub>25</sub>	$M_1W_1S_1P_1I_0$	T <sub>61</sub>	$M_1W_1S_1P_1I_1$	T97	$M_1W_1S_1P_1I_2$	T <sub>133</sub>	$M_1W_1S_1P_1I_3$	T <sub>169</sub>	$M_1W_1S_1P_1I_4$
T <sub>26</sub>	$M_1W_2S_1P_1I_0$	T <sub>62</sub>	$M_1W_2S_1P_1I_1$	T98	$M_1W_2S_1P_1I_2$	T <sub>134</sub>	$M_1W_2S_1P_1I_3$	T170	$M_1W_2S_1P_1I_4$
T <sub>27</sub>	$M_1W_3S_1P_1I_0$	T <sub>63</sub>	$M_1W_3S_1P_1I_1$	T99	$M_1W_3S_1P_1I_2$	T <sub>135</sub>	$M_1W_3S_1P_1I_3$	T <sub>171</sub>	$M_1W_3S_1P_1I_4$
T <sub>28</sub>	$M_1W_1S_2P_1I_0$	T <sub>64</sub>	$M_1W_1S_2P_1I_1$	T <sub>100</sub>	$M_1W_1S_2P_1I_2$	T <sub>136</sub>	$M_1W_1S_2P_1I_3$	T <sub>172</sub>	$M_1W_1S_2P_1I_4$
T29	$M_1W_2S_2P_1I_0$	T <sub>65</sub>	$M_1W_2S_2P_1I_1$	T <sub>101</sub>	$M_1W_2S_2P_1I_2$	T <sub>137</sub>	$M_1W_2S_2P_1I_3$	T173	$M_1W_2S_2P_1I_4$
T <sub>30</sub>	$M_1W_3S_2P_1I_0$	T <sub>66</sub>	$M_1W_3S_2P_1I_1$	T102	$M_1W_3S_2P_1I_2$	T <sub>138</sub>	$M_1W_3S_2P_1I_3$	T174	$M_1W_3S_2P_1I_4$
T <sub>31</sub>	$M_1W_1S_1P_2I_0$	T67	$M_1W_1S_1P_2I_1$	T <sub>103</sub>	$M_1W_1S_1P_2I_2$	T139	$M_1W_1S_1P_2I_3$	T175	$M_1W_1S_1P_2I_4$
T <sub>32</sub>	$M_1W_2S_1P_2I_0$	T <sub>68</sub>	$M_1W_2S_1P_2I_1$	T104	$M_1W_2S_1P_2I_2$	T <sub>140</sub>	$M_1W_2S_1P_2I_3$	T176	$\overline{M_1W_2S_1P_2I_4}$
T <sub>33</sub>	$M_1W_3S_1P_2I_0$	T <sub>69</sub>	$M_1W_3S_1P_2I_1$	T <sub>105</sub>	$M_1W_3S_1P_2I_2$	T <sub>141</sub>	$M_1W_3S_1P_2I_3$	T <sub>177</sub>	$M_1W_3S_1P_2I_4$
T <sub>34</sub>	$M_1W_1S_2P_2I_0$	T70	$M_1W_1S_2P_2I_1$	T <sub>106</sub>	$M_1W_1S_2P_2I_2$	T <sub>142</sub>	$M_1W_1S_2P_2I_3$	T178	$M_1W_1S_2P_2I_4$
T35	$M_1W_2S_2P_2I_0$	T71	$M_1W_2S_2P_2I_1$	T107	$M_1W_2S_2P_2I_2$	T <sub>143</sub>	$M_1W_2S_2P_2I_3$	T179	$\overline{M_1W_2S_2P_2I_4}$
T <sub>36</sub>	$M_1W_3S_2P_2I_0$	T72	$M_1W_3S_2P_2I_1$	T108	$M_1W_3S_2P_2I_2$	T144	$M_1W_3S_2P_2I_3$	T <sub>180</sub>	$M_1W_3S_2P_2I_4$

## **Results and Discussion**

# Available phosphorus (kg $P_2O_5/ha$ ) content in soil as influenced by incubation period, FYM, moisture regimes and levels of P carriers

Phosphorus is one of the major nutrient elements that are required in large amount by crop plants. Because of its high requirement, it has to be added in the soil. However, on entering the soil, it enters into a complex cycle of fixation due to its high reactivity with various ions particularly the Ca, Fe, Al and several organic compounds. The combination of P with different ions and also with different organic compounds or the fixation is affected by type of soil and its chemical composition, regimes of moisture, rate of addition of P and its sources through which, it is added and several other factors. Keeping the above mentioned facts in view a laboratory incubation experiment was conducted at Department of Agricultural Chemistry and Soil Science, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar under controlled condition in the year 2017 to study the effect of different moisture regimes, with and without addition of FYM and levels of P carriers on available phosphorus detected in soil as per the procedure laid down by Olsen *et al.* (1954) <sup>[11]</sup>. The results of the laboratory incubation experiment are discussed here under

## Available phosphorus (kg P<sub>2</sub>O<sub>5</sub>/ha) content in soil

Data pertaining to available phosphorus (kg  $P_2O_5/ha$ ) content in soil as influenced by incubation period, FYM, moisture regimes and levels of P carriers are presented in Table 2.

Table 2	: Effect	of incub	oation j	period,	FYM,	moisture	regime	s and l	evels of	f P	carriers of	n availa	able	phosp	phorus	s (kg	$P_2$	D5/ha)	conten	t in	soil
---------	----------	----------	----------	---------	------	----------	--------	---------	----------	-----	-------------	----------	------	-------	--------	-------	-------	--------	--------	------	------

	$W_1$	$W_2$	<b>W</b> 3	Mo	<b>M</b> <sub>1</sub>	Po	F	<b>P</b> <sub>1</sub>	<b>P</b> <sub>2</sub>	<b>S</b> 1	<b>S</b> <sub>2</sub>	Mean
Io	31.30	35.82	36.55	34.06	35.06	33.16	33	.29	37.22	34.87	34.24	34.56
$I_1$	34.00	63.47	69.67	56.33	55.09	54.14	56	.03	56.96	53.99	57.43	55.71
$I_2$	31.82	42.32	51.13	41.27	42.25	39.46	43	.86	41.96	39.58	43.93	41.76
$I_3$	30.78	40.71	61.86	43.52	45.38	37.92	46	46.97		42.89	46.01	44.45
$I_4$	27.05	41.95	54.16	40.01	42.09	40.69	41	41.82		38.88	43.22	41.05
Mean	30.99	44.86	54.67	43.04	43.97	41.07	44.40		45.05	42.04	44.97	43.50
	Ι	W	$\mathbf{I} \times \mathbf{W}$	Ι	Μ	$\mathbf{I} \times \mathbf{M}$	Ι	Р	I × P	Ι	S	I×S
S.Em. <u>+</u>	0.30	0.23	0.52	0.30	0.19	0.42	0.30	0.23	0.52	0.30	0.19	0.42
C.D. at 5%	0.83	0.64	1.44	0.83	0.52	1.17	0.83	0.64	1.44	0.83	0.52	1.17

The perusals of data regarding the main effects of different factors as well as their interactions are given in Table 2.

All the main effects as well as their interactions significantly affected the content of available  $P_2O_5$  in soil during laboratory experimentation. The soil moisture regimes exerted a significant effect on the availability of  $P_2O_5$  in soil. The behaviour of available  $P_2O_5$  in soil was in the order of  $W_1 < W_2 < W_3$ . The available  $P_2O_5$  content was significantly increased from 30.99 kg/ha under  $W_1$  to 54.67 kg/ha under  $W_3$ .

Maintenance of moisture at 25 per cent FC has ability to maintain moisture at sufficient available moisture range due to this, phosphorus transformation in soil is maintained, which ultimately reflected in increased P availability in soil by maintaining the available moisture in soil. Similar results are also reported by Akbari (1978)<sup>[1]</sup> in green gram and Golakiya (1988)<sup>[8]</sup> in wheat crop. The addition of FYM significantly increased the availability of  $P_2O_5$  in soil from 40.01 to 42.09 kg/ha. The addition of P was found to be significantly increased the content of available  $P_2O_5$  in soil up to  $P_1$  level, but then, it was decreased. While in case of MAP and DAP, DAP proved its significant superiority over MAP with respect to available  $P_2O_5$  content in soil registering significantly higher available  $P_2O_5$  content (43.22 kg/ha).

As far as incubation interval is concerned, they differed significantly in initial stage, however the maximum amount of available  $P_2O_5$  (55.71 kg/ha) was observed under treatment I<sub>1</sub> (3 days) then it was decreased to 41.76 kg/ha under I<sub>2</sub> (05 days) and again it was increased to 44.45 kg/ha by I<sub>3</sub> (07 days), further, it was decreased to 41.05 kg/ha by I<sub>4</sub> (14 days). In general, available  $P_2O_5$  content in soil was remained significantly higher up to I<sub>4</sub> (14 days) over initial incubation period I<sub>0</sub>. As far as interaction between incubation interval and moisture regimes is concerned, the significant trend was observed. The maintenance of moisture at 25 per cent for 3 days (I<sub>1</sub>W<sub>3</sub>) showed significantly higher concentration of available  $P_2O_5$  (69.67 kg/ha) content in soil. While

combination  $I_4W_1$  registered significantly the lowest value (27.05 kg/ha) of available  $P_2O_5$  content in soil.

The addition of FYM @ 10 t/ha for 3 days incubation  $(I_1M_1)$  resulted in significantly higher amount of available P<sub>2</sub>O<sub>5</sub> (56.33 kg/ha). Although, it is surprisingly to know that with the addition of FYM resulted in the lowest value (40.01 kg/ha) of available P<sub>2</sub>O<sub>5</sub> content in soil up to 14 days. Addition of phosphorus @ 2.34 mg P/100 g soil incubated for 3 days (I<sub>1</sub>P<sub>2</sub>) gave higher concentration of available P<sub>2</sub>O<sub>5</sub> content in soil. But, it was at par with I<sub>1</sub>P<sub>1</sub>. The lowest value was observed under I<sub>0</sub>P<sub>0</sub> combination (33.16 kg/ha) but statistically, it was at par with I<sub>0</sub>P<sub>1</sub>.

While studying the interaction effect of incubation period vs. sources of P fertilizers, DAP incubated for 3 days registered significantly higher (57.43 kg/ha) concentration of available  $P_2O_5$  but, if DAP is incubated for one day only exerted the lowest available  $P_2O_5$  content (34.24 kg/ha) in soil. Maintenance of moisture at a lower level that is 25 per cent and application of phosphatic fertilizers @ 2.34 mg P/100 g soil (W<sub>3</sub>P<sub>2</sub>) found to increase significantly the available  $P_2O_5$  content (56.49 kg/ha) in soil. While,  $W_1P_0$  combination registered lower value of (24.80 kg/ha) available  $P_2O_5$  content in soil. It was observed that maintenance of moisture at a lower level for DAP significantly increased the available  $P_2O_5$  content in soil. But at a higher level maintenance of moisture (75%) for MAP registered significantly lower value of available  $P_2O_5$  content in soil.

Maintenance of moisture at a higher level with application of FYM ( $W_3M_1$ ) was found to record higher concentration of available  $P_2O_5$  (55.51 kg/ha) content in soil. But same level of water regimes without the application of FYM @10 t/ha recorded 53.84 kg/ha available  $P_2O_5$  content in soil. An application of DAP @ 2.34 mg P/100 g soil was found to gave significantly higher value (47.33 kg/ha) of available  $P_2O_5$  content in soil as compared to without application of phosphatic fertilizers by any source.

An application of FYM @ 10 t/ha along with P fertilizers @ 1.34 mg P/100 g soil exerted significantly higher value of available  $P_2O_5$  content (45.97 kg/ha) in soil. An application of FYM @ 10 t/ha along with DAP combination  $S_2M_1$  gave significantly higher available  $P_2O_5$  content (46.16 kg/ha) in soil.

Dotaniya et al. (2014) [3] also observed and concluded that application of organic residue reduced the P fractions namely, Al-P and Ca-P in an Inceptisol. While, available P (Olsen-P) in soil solution increased with higher levels of organic residue as well as increasing incubation time. Thus, organic residues should be incorporated into soils for *in-situ* mobilization of nonlabile P into available forms, thereby maintain soil solution P in long ways. Kaloi et al. (2011)<sup>[10]</sup> also observed the similar trend of availability of P in two different soils of Hyderabad. They observed that the release of phosphorus was increased with increasing incubation time up to 7 days after that, it was decreased with time. They revealed that highest dose of P gave the maximum availability at each sampling days of incubation period. Opala et al. (2012) [12] studied the application of organic materials (FYM) along or in combination with inorganic P sources and stated that among the sources of organic materials the FYM was more effective. The findings of Hanif et al. (2015) [9], Giroto et al. (2017) [7], Rajonee et al. (2017)<sup>[13]</sup>, Gichangi et al. (2009)<sup>[6]</sup> and Gagnon et al. (2012)<sup>[4]</sup> are in agreement with the results of the present investigation.

## Conclusions

Available  $P_2O_5$  content in soil was significantly increased by maintaining available water capacity from 100% (W<sub>1</sub>) to 25% (W<sub>3</sub>). Application of FYM @ 10 t/ha significantly increased available  $P_2O_5$  content in soil. The phosphorus availability in soil was significantly increased with increasing the rate of P application. Among the two carriers of P, DAP was found superior over MAP with respect to availability of phosphorus in soil. The availability of phosphorus in soil was increased as the incubation interval was raised from 01 to 14 days, but it was found the highest after three days interval.

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