



Effect of Moisture Regimes, FYM and Levels of Phosphorus Carriers on Growth, Yield Attributes and Yield by Potato (*Solanum tuberosum* L.)

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ABSTRACT

Background: Potato (*Solanum tuberosum* L.) ranks fourth in terms of worldwide production. The states of Uttar Pradesh, West Bengal, Bihar and Gujarat accounted for more than 80 per cent share in total production; India ranks second, next to China in global production of potato. Potato crop is extremely sensitive to the deficit or surplus moisture and requires an optimum amount of irrigation at frequent intervals for its proper growth. Phosphorus (P) is an element that is potatoes require in large amounts following Nitrogen and Potassium, P application rates influence on the P efficiency for tuber yield and P uptake.

Methods: 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 potato variety *Kufri pukhraj* as test crop.

Result: Among different moisture regimes tested, the treatment receiving maintenance of moisture between 100 and 75 per cent availability at 0-30 cm soil depth (W_1) gave significantly higher plant height (52.24 cm), number of tubers per plant (6.74), total tuber yield (335.74 q/ha) and haulm yield (16.64 q/ha) during pooled results. Combinations of FYM and levels of P carriers tested, the treatment combinations FYM and application of P @ 180 kg P_2O_5 /ha in the form of MAP($P_3S_1M_1$) showed significantly higher plant height (50.04 cm), tuber per plant (6.87), total tuber yield (323.98 q/ha) and haulm yield (17.16 q/ha) gave during pooled results.

Key words: Moisture regimes, P carriers, Phosphorus levels, Potato.

INTRODUCTION

After maize, wheat and rice, potato (*Solanum tuberosum* L.) ranks fourth in terms of worldwide production (Bruinsma 2017). The worldwide potato production was appraised at 388,191,000 Mg/ha in 2017 (FAOSTAT, 2019). The globe potato segment is undergoing major changes. Until the early 1990s, most potatoes were grown and consumed in Europe, North America and countries of the former Soviet Union. Since then, there has been a dramatic increase in potato production and demand in Asia, Africa and Latin America, where output rose from less than 30 million tonnes in the early 1960s to more than 165 million tonnes in 2007 (Source: <https://www.potatopro.com/world/potato-statistics>). Potato has now become one of the most popular crops in India and cultivated in almost all states and under very diverse agro-climate conditions. The states of Uttar Pradesh, West Bengal, Bihar and Gujarat accounted for more than 80 per cent share in total production; India ranks second, next to China in global production of potato (Source: <https://www.potatopro.com/india/potato-statistics>). India produces more than 43.77 million tonnes of potatoes from an area of 2.13 million hectares with an average yield of 20515 kg/ha (Anonymous, 2016).

Potato crop is extremely sensitive to the deficit or surplus moisture and requires an optimum amount of irrigation at frequent intervals for its proper growth (Kashyap and Panda 2003). In water-scarce areas, frequent irrigation to the crops is difficult due to the stressed water resources

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and increased demand for other purposes. This necessitates an improvement in the water use efficiency to fulfil the water requirement of the crops (Poddar *et al.* 2018). Several investigators used the water balance approach to study the crop water requirements, soil moisture dynamics, crop coefficients and irrigation schedules for potato crop (Stalham and Allen 2004).

Phosphorus (P) is an element that is potatoes require in large amounts following Nitrogen and Potassium, P application rates influence on the P efficiency for tuber yield and P uptake (Jasim *et al.*, 2020). P also plays a fundamental role in crop and vegetable physiology. Energy storage and transfer are the most important functions of P in plants (Bruulsema *et al.* 2019). The P deficiency suppresses and delays potato growth and maturity (Hopkins and Hansen 2019). The plants that are grown under P stress are generally stunted, with darker green-collared leaves. When the P deficiency is exacerbated, the dark green colour changes to greyish-green or bluish-green (Chalker-Scott 1999). Moreover, incorporation of FYM not only provides almost all nutrients but also helps in providing balanced nutrition to the crop which is reflected in terms of better growth and development, and subsequently higher yield (Ibeawuchi *et al.* 2007). These sources reduce the mining of soil nutrient and improve soil organic carbon, humus and overall soil productivity (Jenssen 1993). It was reported that FYM increased the tuber yield by 43-45.3% (Ilin 1992) by a long residual effect, supporting better growth and development (Abou *et al.* 2005). It serves as a slow release of nutrients to the crop (Upadhyay *et al.*, 2003).

MATERIALS AND METHODS

The experiment was laid out on Plot No. B-10 at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University (SDAU), Sardarkrushinagar during *rabi* seasons of the year 2017-18 and 2018-19. Geographically, the SDAU, Sardarkrushinagar situated in the North Gujarat Agro-climatic region (Zone IV). The climate of this region is sub-tropical monsoon type and falls under semi-arid region. In general, monsoons are warm and moderately humid and summer season (March-June) is

generally hot and dry. The winter season sets in the middle of October and continues till middle of February the minimum temperature of the both season is observed either in the month of December or January. The overall climatological data indicated that the weather conditions were observed normal and favourable for the satisfactory growth and development of the potato crop during the *rabi*, 2017-18 and 2018-19.

The experimental field has even topography with gentle slope and good drainage. The soil samples were drawn randomly from different places of experimental site up to a depth of 0 to 15 cm before the sowing of crop (Table 1). The soil was low in organic carbon and available nitrogen, medium in available P_2O_5 , K_2O and DTPA-extractable Fe and Zn and having sufficient DTPA-extractable Mn and Cu status. The *Kufri Pukhraj* potato was selected for this investigation because of its heat resistant, early producing and high yielding.

Experimental and cultural operations details of field study

A. Main plot treatment: 03

W_1 = Maintenance of moisture between 100 and 75% availability at 0-30 cm soil depth.

W_2 = Maintenance of moisture between 100 and 50% availability at 0-30 cm soil depth.

W_3 = Maintenance of moisture between 100 and 25% availability at 0-30 cm soil depth.

B. Sub-plot treatments: 12

1. Levels of P: 03

P_1 = 100 kg P_2O_5 /ha.

P_2 = 140 kg P_2O_5 /ha.

P_3 = 180 kg P_2O_5 /ha.

2. Sources of P: 02

S_1 = Monoammonium Phosphate (MAP).

S_2 = Diammonium Phosphate (DAP).

Table 1: Initial properties of the experimental plot before sowing of potato crop at 0-15 cm soil depth.

Properties	Unit	2017-18	Method used
Coarse sand	%	44.76	International pipette method, Piper (1966)
Fine sand	%	40.18	
Silt	%	7.90	
Clay	%	7.16	
pH(1:2.5) at 25°C	-	7.5	Potentiometry, Jackson (1973)
EC (1:2.5) at 25°C	dS/m	0.18	Conductivity meter, Jackson (1973)
Organic carbon	%	0.24	Modified walkley and Black method
Available N	kg/ha	214.32	Alkaline $KMnO_4$ method, Subbiah and Asija (1956)
Available P_2O_5	kg/ha	32.95	Olsen's method, Olsen <i>et al.</i> (1954)
Available K_2O	kg/ha	240.40	Neutral N NH_4OAc Flame photometry method, Jackson (1973)
Available Fe	mg/kg	7.82	Atomic absorption spectroscopy, Lindsay and Norvell (1978)
Available Mn	mg/kg	12.20	
Available Zn	mg/kg	0.81	
Available Cu	mg/kg	0.52	

3. FYM: 02

$M_0 = 0$ t/ha.

$M_1 = 20$ t/ha.

The present experiment was laid out in Split Plot Design (SPD) with three replications, 36 treatment combination and 108 total numbers of experimental plots at 6×4.5 m (9 line) gross and 5.2×3.5 m (7 line) net plot size as per plan of lay-out. Potato tubers of variety *Kufri Pukhraj* were cut in pieces, keeping two to three live eye buds with approximately 30 to 35 g weight. Cut pieces were treated with the mixture of Mancozeb @ 1 kg/ha + Talc powder @ 5 kg/ha before planting to control rotting of cut pieces of potato tubers. The treated cut pieces of potato tubers were planted 20 cm apart in opened furrows with seed rate @ 3000 kg tubers/ha on 18th November and on 20th November during 2017 and 2018, respectively.

Two common irrigations were applied i.e. first irrigation was given immediately after planting and second irrigation was on 5th day after first irrigation for facilitating easy germination of the 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 0-30 cm for determining the needs of irrigation. The statistical analysis of the data generated during the course of investigation was carried out through software on computer following the procedure described by Cochran and Cox (1967).

RESULTS AND DISCUSSION

The statistics given in Fig 1 (A) showed that the plant height measured at harvest was significantly influenced due to different treatments it's diverse from 41.18 to 52.24 cm. Maintenance of moisture between 100 and 75 % availability at 0-30 cm soil depth gave significantly higher plant height (50.13, 54.35 and 52.24 cm). Whereas, combination $P_3S_1M_1$ showed significantly higher plant height as compared to other treatment combinations except $P_1S_2M_0$, $P_1S_2M_1$, $P_2S_2M_1$, $P_3S_2M_1$ which was at par with $P_3S_1M_1$, during both of the years and pooled results, respectively. Potato is the water loving plant therefore under or over supply of irrigation water may affect growth, yield and quality of the crop. Both the productivity and quality of produce largely depend on a proper balance between soil air and soil moisture available in the plant root zone throughout the crop growth period, which can only be achieved by adopting a sound water management practices (Singh *et al.*, 2012). Potato crop is very sensitive to insufficient fertilizer doses and very responsive to higher doses of fertilizers. A perusal of data [Fig 1 (B)] revealed that the maintenance of moisture W_1 level recorded significantly more number of tubers per plant over rest of treatments. Among the levels of P carriers with and without application of FYM, combination $P_3S_1M_1$ showed

significantly higher number of tuber per plant (6.40, 7.34, and 6.87) as compared to other treatment combinations.

Maintenance of moisture between 100 and 25% availability at 0-30 cm soil depth (W_3) produced significantly more small size tuber (< 25 g) yield (14.45, 15.69 and 15.07 q/ha during 2017-18, 2018-19 and in pooled results, respectively) as compared to W_1 and W_3 moisture regimes [Fig 1 (C)]. An adequate water supply is required from tuber initiation till the maturity for higher yield and good tuber quality. Moisture stress, especially at the most critical stages like stolen formation, tuber formation and tuber development, results sharp decline in potato productivity (Saikia, 2011). The data [Fig 1 (C), (D) and (E)] on small size tuber yield of potato after harvest as affected by treatment combination $P_3S_1M_1$ (180 kg P_2O_5 /ha + MAP + FYM @ 20 t/ha) was recorded significantly highest small (13.24, 15.25 and 14.24 q/ha), medium (34.28, 35.66 and 34.97 q/ha) and large (273.37, 276.15 and 274.76 q/ha) size tuber yield during 2017-18, 2018-19 and pooled result, respectively.

Among different treatments tested, maintenance of moisture W_1 produced significantly higher total tuber yield of potato as compared to other moisture regimes. An increase in total tuber yield of potato due at W_1 moisture regimes was to the tune of 23.37% over W_3 moisture regime (Table 2). As far as the effect of different combinations of FYM and levels of P carriers on potato tuber yield was concerned, it was observed that yield of tuber with FYM and application of P @ 180 kg P_2O_5 /ha in the form of MAP ($P_3S_1M_1$) was significantly higher (320.90, 327.06 and 323.98 q/ha during 2017-18, 2018-19 and pooled result, respectively) over all the treatment combinations except $P_2S_2M_1$ (310.57 q/ha) and $P_3S_2M_1$ (317.82 q/ha).

Among the regimes of moisture, moisture level W_1 and W_2 were significantly yielded more haulm effect of different combinations of FYM and levels of P carriers on potato haulm yield was concerned [Fig 1 (F)], it was observed that yield of haulm with FYM and application of P @ 180 kg P_2O_5 /ha in the form of MAP ($P_3S_1M_1$) was significantly higher (16.23, 18.09 and 17.16 q/ha during 2017-18, 2018-19 and pooled basis, respectively) as compare to allover treatment combinations. 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. Response of FYM majored as kg grain was highest in wheat (Mahapatra *et al.*, 2007). 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. Shahi *et al.* (2015) and Patel *et al.* (2020) also revealed in their studies that an application of P at a higher level in the form of MAP showed higher and significant response.

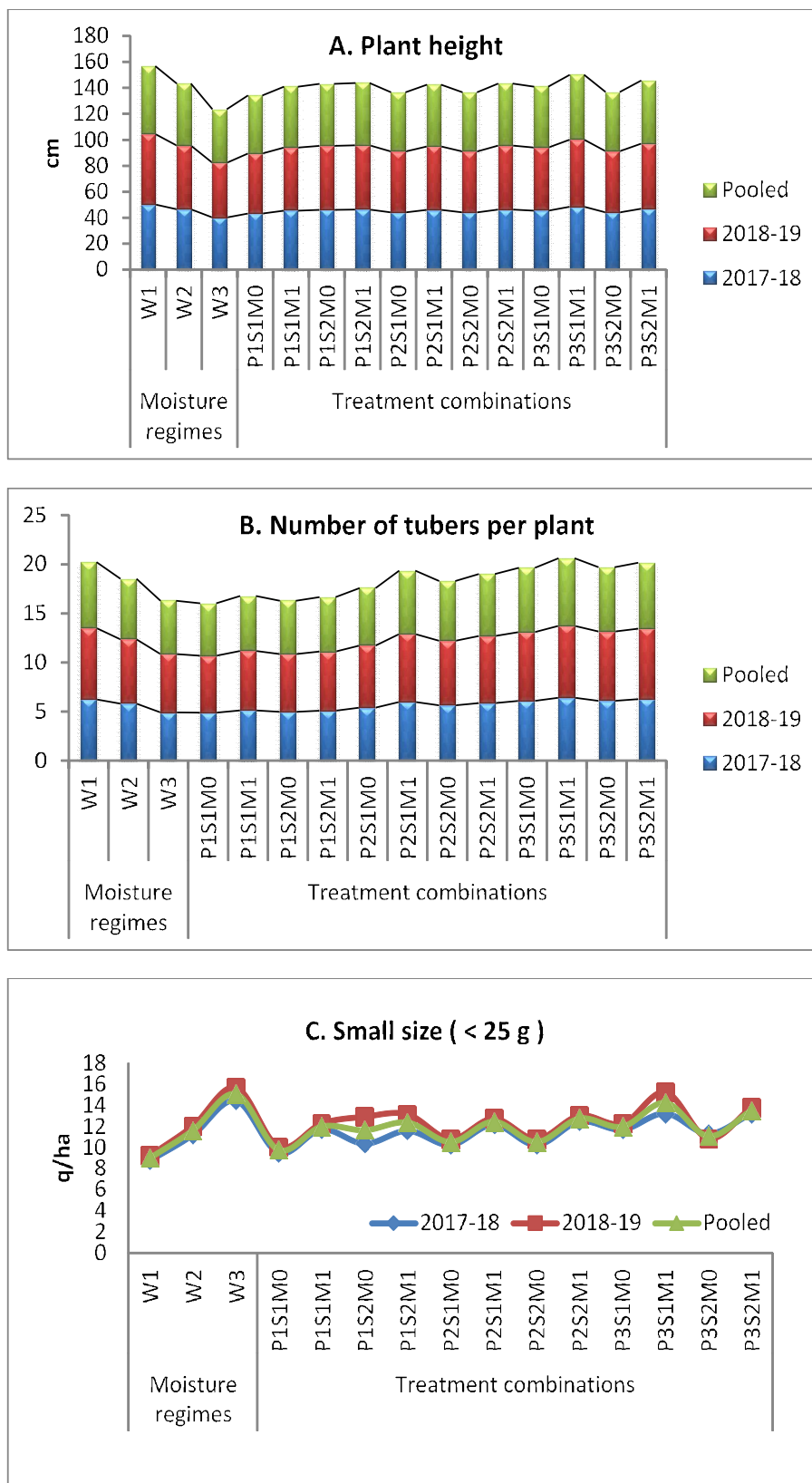


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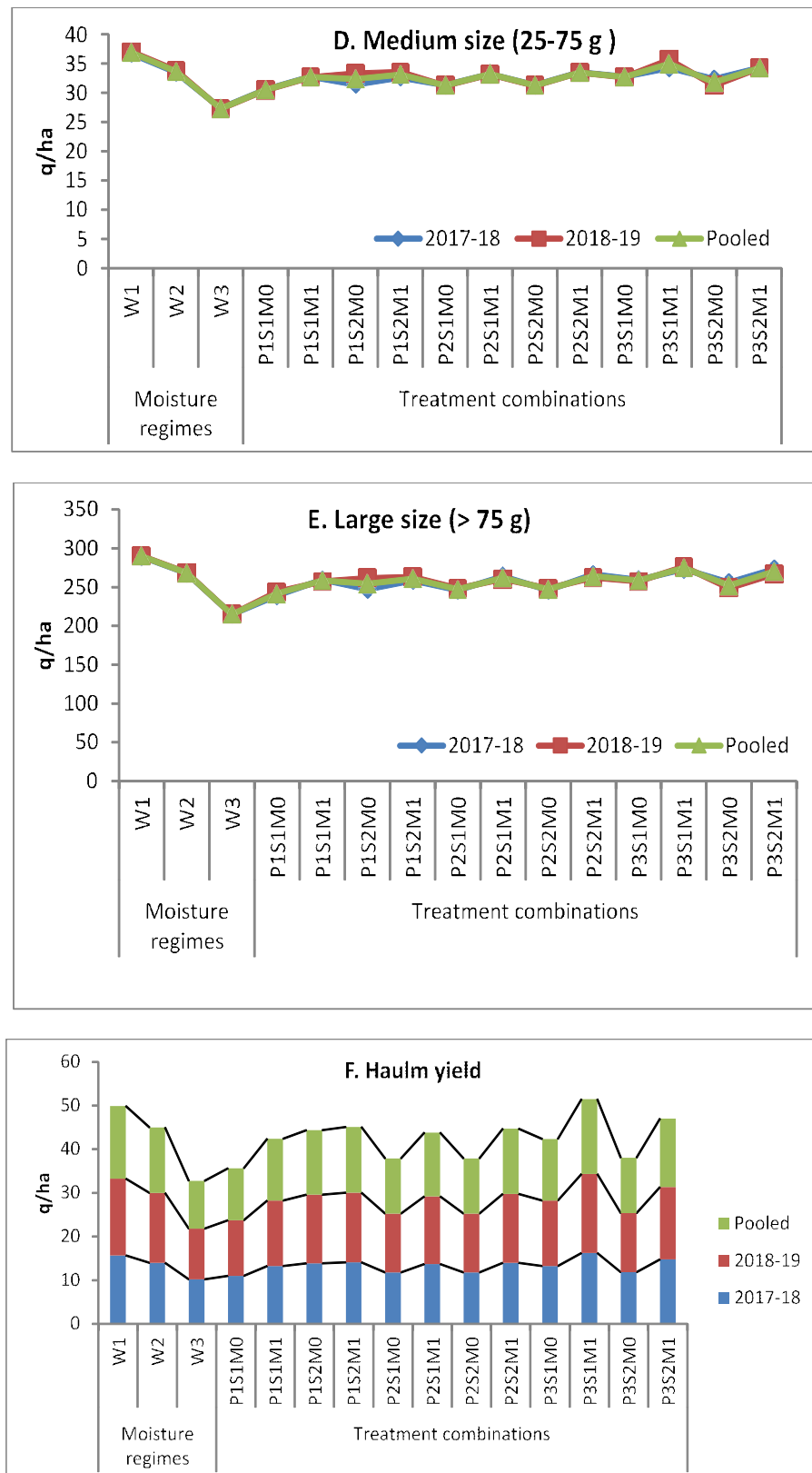


Fig 1: Effect of moisture regimes and combinations of FYM and levels of P carriers on Plant height (A), Number of tubers per plant at harvest (B), Small size tubers (C), Medium size tubers (D), Large size tubers (E) and Haulm yield (F).

Table 2: Effect of moisture regimes and combinations of FYM and levels of P carriers on total tuber yield of potato.

Treatments	Total tuber yield (q/ha)		
	2017-18	2018-19	Pooled
W ₁	334.83	336.65	335.74
W ₂	312.73	314.61	313.67
W ₃	256.73	257.83	257.28
S.Em.±	5.23	4.67	4.05
C.D. at 5%	20.55	18.34	13.21
P ₁ S ₁ M ₀	279.48	284.35	281.91
P ₁ S ₁ M ₁	303.99	302.57	303.28
P ₁ S ₂ M ₀	289.07	307.90	298.48
P ₁ S ₂ M ₁	302.66	309.81	306.24
P ₂ S ₁ M ₀	287.79	290.53	289.16
P ₂ S ₁ M ₁	309.16	306.41	307.78
P ₂ S ₂ M ₀	287.75	290.50	289.13
P ₂ S ₂ M ₁	312.35	308.78	310.57
P ₃ S ₁ M ₀	303.91	302.51	303.21
P ₃ S ₁ M ₁	320.90	327.06	323.98
P ₃ S ₂ M ₀	299.45	290.98	295.22
P ₃ S ₂ M ₁	320.67	314.97	317.82
S.Em.±	7.23	6.28	5.53
C.D. at 5%	20.41	17.73	15.46

CONCLUSION

In the loamy sand (*Typic Ustipsammments*) of North Gujarat, maintenance of moisture between 100 and 75 per cent availability at 0-30 cm depth and an application of FYM @ 20 t/ha along with 180 kg P₂O₅/ha through MAP was found more advantageous in terms of growth, yield attributes and yield.

Conflict of interest: None.

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