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Response of Soil Moisture Regime of Relay Grass Pea (*Lathyrus sativus* L.) to Seed Priming and Foliar Fertilization in New Alluvial Zone of West Bengal

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ABSTRACT

Background: Indian agricultural sector requires a huge consumption of total available water for the sake of optimum crop production. The modern era of water scarcity necessitates the escalation of water use efficiency of crops to secure higher portion of economic harvests per drop use of water in agriculture. Against this background, it is requires to introduce lesser water consuming crops like pulses, oilseeds *etc* with innovative and cost-effective agronomic interventions for the purpose of contributing towards conservation of more water.

Methods: A field experiment was conducted at District Seed Farm, 'A-B' Block of Bidhan Chandra Krishi Viswavidyalaya, West Bengal, during subsequent winter seasons of 2017-18 and 2018-19 to evaluate the effect of seed priming with molybdenum and foliar fertilization on moisture utilization of relay grass pea, variety Ratan (Bio L-212) without irrigation, using seed priming with Ammonium molybdate and foliar spray of 2% Urea and 0.5% NPK(19:19:19) in different combinations.

Result: Maximum water use efficiency of 16.65 and 14.80 kg ha^{-1} mm^{-1} in the respective years were recorded with seed priming combined with twice foliar spray of 0.5% NPK (19:19:19) with the highest yield and moisture consumption. Total soil moisture content was found to be an exponential function of dry aerial biomass, but shared a polynomial correlation with leaf area index at different growth stages of grass pea. However, water use efficiency exhibited strong and polynomial correlation with seed yield and stover yield of grass pea in both the years. The combination of seed priming with Ammonium molybdate @ 0.5 g kg^{-1} seed along with a twice foliar spray of 0.5% NPK (19:19:19) will be a profitable technology for the relay grass pea growers in new alluvial zone of West Bengal.

Key words: Foliar fertilization, Grass pea, Relay cropping, Seed priming, Water use efficiency.

INTRODUCTION

In a country, generally, the lion's share of water is utilized for agriculture in the form of irrigation. With the development of societies, the requirement for water for non-agricultural purposes rises. Automatically, there is a gradual decline in the availability of water for the agricultural sector. Moreover, changing the environmental scenario adds more to this worldwide deficit of water. Under these circumstances, the principal challenge to combat water scarcity in agriculture is to boost up water use efficiency to ensure more crop per drop use of water (Vadez *et al.*, 2011; Saravanan *et al.*, 2018).

In India, pulse crops like chickpea, lentil, grass pea are raised by utilizing the residual soil moisture under rice fallows. Among them, grass pea (*Lathyrus sativus* L.) is an outstanding crop to endure moisture stress (Gusmao *et al.*, 2012; Kalita and Chakrabarty, 2017). Commonly it is grown as a relay crop by utilizing the left out soil moisture after winter rice (Bhowmick *et al.*, 2014; Navaz *et al.*, 2017). The excellent ability of grass pea to flourish with minimal external inputs (Nazrul and Shaheb, 2015) under adverse climatic situations like temperature extremes, very poor soil types (Dixit *et al.*, 2016) has enlighted the crop as 'poor man's pulse crop' (Parihar and Gupta, 2016).

Under field conditions, difficulties for cultivation under rice fallow like poorly fertile soil, rapid depletion in soil moisture reserve after *kharif* rice harvest lead to drop in production potential (Bhowmick *et al.*, 2014). To confront these adversities, seed priming is a fantastic pre-sowing way out through partial hydration of seeds which stimulates the metabolic activity of seeds, improving seed germination characteristics (Pakbaz *et al.*, 2014; Aliloo *et al.*, 2014). Priming increases crop yield due to accelerated crop growth and early flowering (Kaur *et al.*, 2005) which allows the crop to escape the late-season drought and heat stresses. Besides, there are several literature regarding mitigation of moisture stress through foliar application of agrochemicals *i.e.*, urea, potassium chloride, boron, *etc.* in relay *rabi* crops (Math *et al.*, 2014; Yadav *et al.*, 2019) at the flowering stage when the crops face terminal moisture stress due to continuous decrease in soil moisture. A crop grown under

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receeding moisture conditions devoid of irrigation experiences water deficit at critical stages, which hampers the nutrient uptake and final yield. Foliar nutrition with N at the reproductive stage of pulses may aid in the alleviation of nitrogen deficiency (Das and Jana, 2016). Side by side, a sufficient supply of P and K can curtail the negative impacts of drought stress through osmo-regulation and maintenance of leaf water potential.

For the upliftment of production during this moisture stress period, maintenance of plant water regime through improved uptake mechanisms as well as the elimination of excess loss moisture through processes like transpiration are of serious concern. The present experiment was planned to standardize the most effective schedule of seed priming and foliar fertilization for relay grass pea for better use of residual soil moisture for enhancement of production potential of relay sown grass pea in a new alluvial zone of West Bengal.

MATERIALS AND METHODS

A two years field experiment was conducted at District Seed Farm, 'A-B' block, (22°93' N latitude, 88°53' E longitude and 9.75 m above mean sea level) of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal, India during two subsequent winter seasons (October-March) of 2017-18 and 2018-19. The experimental soil was sandy loam in texture with pH 7.3, EC 0.18 dS m^{-1}, organic carbon 0.56%, available N 231.28 kg ha^{-1}, P_2O_5 34.51 kg ha^{-1}, available K_2O 188.83 kg ha^{-1}. The experiment was laid out in a factorial randomized block design replicated thrice comprising two seed priming levels *viz.* S_1: No seed priming and S_2: Seed priming with Ammonium molybdate @ 0.5 g kg^{-1} seed and five foliar spray levels *viz.* F_1: No foliar spray, F_2: 2% Urea spray at pre-flowering stage, F_3: 2% Urea spray at pre-flowering stage + 15 days after 1st spray, F_4: 0.5% NPK (19:19:19) spray at pre-flowering stage and F_5: 0.5% NPK (19:19:19) spray at pre-flowering stage+15 days after 1st spray. Grass pea [Variety Ratan (Bio L-212)] seeds were broadcasted @ 80 kg ha^{-1} treated with *Rhizobium* biofertilizer @ 20 g kg^{-1} of seed a week before harvesting of rice crop [variety Satabdi (IET 4786)] in both the years. Application of basal dose of fertilizers and irrigation were completely excluded for grass pea cultivation. Total rainfall amounting to 9.4 and 1.4 mm were received during the crop growth period, whereas the mean maximum temperature of 28.2 and 28.3°C and minimum temperatures of 16 and 15.2°C were recorded in the first and second year of experimentation, respectively. The following formulae were used to calculate various parameters:

Soil moisture content (%) =

$$\frac{\text{Fresh weight of soil (g)} - \text{Dry weight of soil (g)}}{\text{Dry weight of soil (g)}} \times 100$$

(Black, 1965)

Soil moisture content (mm) =

$$\text{Soil moisture content (\%)} \times \text{Ai} \times \text{D}$$

(Black, 1965)

Where,

Ai = Apparent specific gravity of soil (or, bulk density of soil, dimensionless).

D = Depth of soil (mm).

$$\text{Leaf area index (LAI)} = \frac{\text{Leaf area}}{\text{Ground area}}$$

(Watson,1952)

Profile water contribution (ΔS) =

$$\sum \frac{\text{Ms} - \text{Mh}}{100} \times \text{Ai} \times \text{D}$$

(Black, 1965)

Where,

ΔS = Profile water contribution (mm).

Ms, Mh = Moisture content of the soil (%) at sowing and harvest, respectively.

Seasonal consumptive use of water (CU) =

$$\text{ER} + \text{IR} + \Delta S$$

(Anonymous, 1962)

Where,

CU = Consumptive use of water by a crop during the entire growing season (mm).

ER = Effective rainfall during that crop growing season (mm).

IR = Irrigation water applied to the crop (mm).

Water use efficiency (kg/ha-mm) =

$$\frac{\text{Seed yield (kg/ha)}}{\text{Consumption use of water (mm)}}$$

(Abbate *et al.*, 2004)

Data obtained from different parameters were analyzed by the method of analysis of variance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Total soil moisture status in the soil column at different growth stages of *Lathyrus*

Overall soil moisture reserve was gradually decreased throughout the growing season of grass pea irrespective of seed priming and foliar spray levels as the crop was solely dependent on the residual soil moisture. Fig 1 and Fig 2 revealed that total soil moisture content in the soil column was maximum at the branching period. However, the moisture content of the soil column was higher during the 1st year due to the higher amount of rainfall received as compared to the 2nd year. Seed priming with Ammonium molybdate @ 0.5 g kg^{-1} seed following 0.5% NPK (19:19:19) spray at pre-flowering and 15 days after 1st spray *i.e.*, S_2F_5 recorded minimum total soil moisture content at flowering (47.16 and 48.30 mm), pod development stage (31.93 and 19.46 mm) and at harvest (15.19 and 9.26 mm) during both the years respectively (Table 1) implying maximum water uptake. However, the treatment without seed priming and foliar fertilization *i.e.*, S_1F_1 recorded maximum moisture content in the soil in those mentioned stages.

The treatment S_2F_5 was found with the lowest amount of moisture reserve possibly due to higher water uptake by the plants. Phosphorous augmented deeper root proliferation that helped in better water uptake than the other treatments. Potassium has been reported to reduce the negative effects of soil moisture stress in crop plants (Sadaf and Tahir, 2017; Chaudhari *et al*., 2018). More specifically, the presence of potassium in the foliar sprays prevented excess moisture loss through transpiration by the closure of stomata (Subbaramma *et al*., 2017) along coupled with greater uptake of soil moisture (Zain *et al*., 2014) under deficit moisture conditions.

Dry aerial biomass and leaf area index are important parameters indicating the moisture uptake pattern of a crop (Table 2). Advancement in these parameters implies improved water uptake and consumption in plants. Total soil moisture content was found to be an exponential function of dry aerial biomass in both years (Fig 3). On the other hand, leaf area index of grass pea was found to

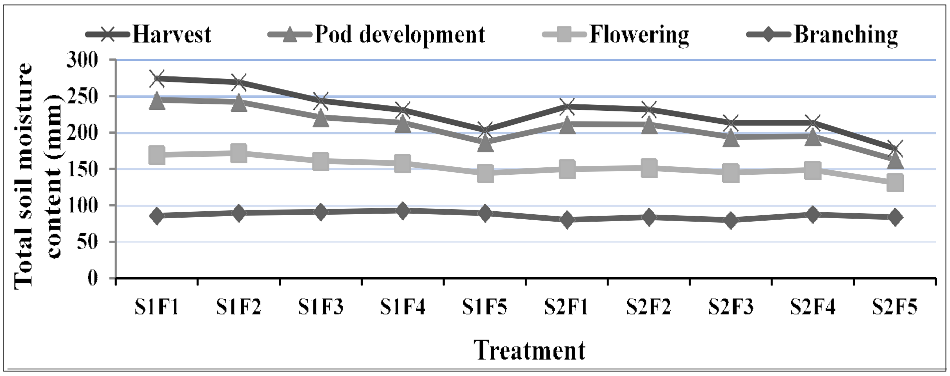

Fig 1: Total soil moisture content at different growth stages of lathyrus during 2017-18.

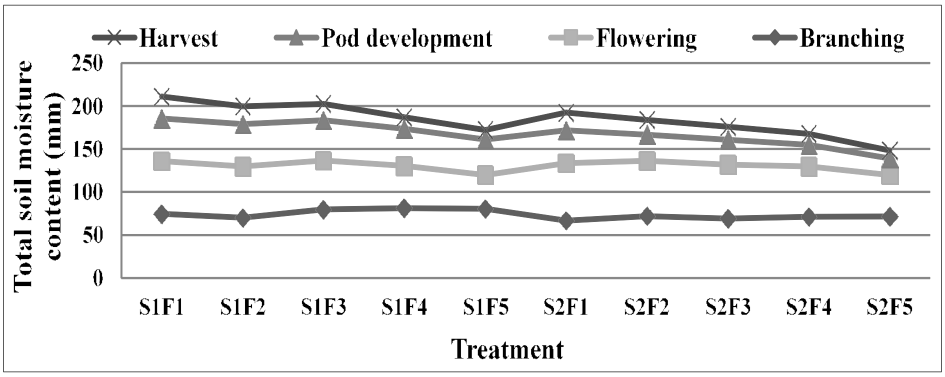

Fig 2: Total soil moisture content at different growth stages of lathyrus during 2018-19.

Table 1: Total soil moisture status at different growth stages of grass pea in relation to seed priming and different foliar sprays of nutrients.

Treatment	Total soil moisture status (0-45 cm depth) (mm)							
	2017-18				2018-19			
	Branching	Flowering	Pod development	Harvest	Branching	Flowering	Pod development	Harvest
S_1F_1	85.74	83.46	75.79	29.25	74.83	61.22	49.67	25.46
S_1F_2	89.89	81.86	70.31	26.98	70.22	59.63	49.26	20.61
S_1F_3	90.98	70.07	59.91	22.78	79.67	56.85	47.12	18.75
S_1F_4	92.85	64.88	55.74	17.64	81.19	49.31	42.86	13.59
S_1F_5	89.23	55.14	42.49	16.69	80.48	39.26	41.4	10.84
S_2F_1	80.23	69.69	61.52	24.08	66.9	66.73	38.04	20.79
S_2F_2	83.55	67.74	59.59	20.87	71.85	64.29	30.47	17.23
S_2F_3	79.91	65.04	49.01	19.54	69.17	62.61	29.06	14.98
S_2F_4	87.24	61.24	46.09	18.88	71.31	58.59	24.94	12.68
S_2F_5	83.81	47.16	31.93	15.19	71.46	48.3	19.46	9.26
S.Em(±)	1.82	0.86	0.62	0.61	0.51	0.59	0.55	0.56
C.D. (P=0.05)	NS	2.56	1.87	1.83	1.53	1.78	1.64	1.67

*S_1- No seed priming; S_2- Seed priming with Amm. molyb. @ 0.5 g/ kg seed;
F_1- No foliar spray; F_2- 2% Urea (once); F_3- 2% Urea (twice); F_4- 0.5% NPK 19:19:19 (once); F_5- 0.5% NPK 19:19:19 (twice).

Table 2: Dry aerial biomass accumulation and leaf area index (LAI) of lathyrus at different growth stages as influenced by seed priming and different foliar sprays of nutrients.

Treatment	Dry aerial biomass (g m^{-2})						Leaf area index (LAI)					
	2017-18			2018-19			2017-18			2018-19		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
S_1F_1	34.79	80.16	203.87	39.17	85.04	209.11	0.26	0.82	1.28	0.26	0.84	1.30
S_1F_2	36.10	107.63	251.80	39.67	110.79	256.94	0.27	0.86	1.34	0.26	0.86	1.37
S_1F_3	34.45	116.03	305.73	38.76	122.24	310.73	0.28	0.86	1.40	0.27	0.86	1.42
S_1F_4	33.81	132.74	323.57	37.72	137.00	331.67	0.27	0.89	1.46	0.27	0.91	1.47
S_1F_5	34.56	139.93	344.95	37.76	137.17	352.77	0.25	0.88	1.50	0.27	0.91	1.51
S_2F_1	50.46	101.93	226.17	48.21	107.74	234.61	0.29	0.86	1.35	0.30	0.88	1.33
S_2F_2	49.76	135.93	315.03	49.77	140.22	321.82	0.31	0.89	1.42	0.31	0.90	1.42
S_2F_3	50.61	144.06	336.36	49.19	148.94	344.04	0.31	0.90	1.47	0.30	0.90	1.46
S_2F_4	51.09	160.50	352.42	50.90	167.19	360.46	0.30	0.93	1.52	0.31	0.95	1.50
S_2F_5	50.41	167.38	377.80	50.28	175.79	385.86	0.30	0.92	1.56	0.30	0.94	1.56
S.Em(±)	1.34	1.31	3.81	2.03	3.89	2.91	0.008	0.005	0.007	0.01	0.007	0.008
C.D. (P=0.05)	NS	NS	11.42	NS	NS	8.73	NS	NS	NS	NS	NS	NS

* S_1- No seed priming; S_2- Seed priming with Amm. molyb. @ 0.5 g/ kg seed;
F_1- No foliar spray; F_2- 2% Urea (once); F_3- 2% Urea (twice); F_4- 0.5% NPK 19:19:19 (once); F_5- 0.5% NPK 19:19:19 (twice).

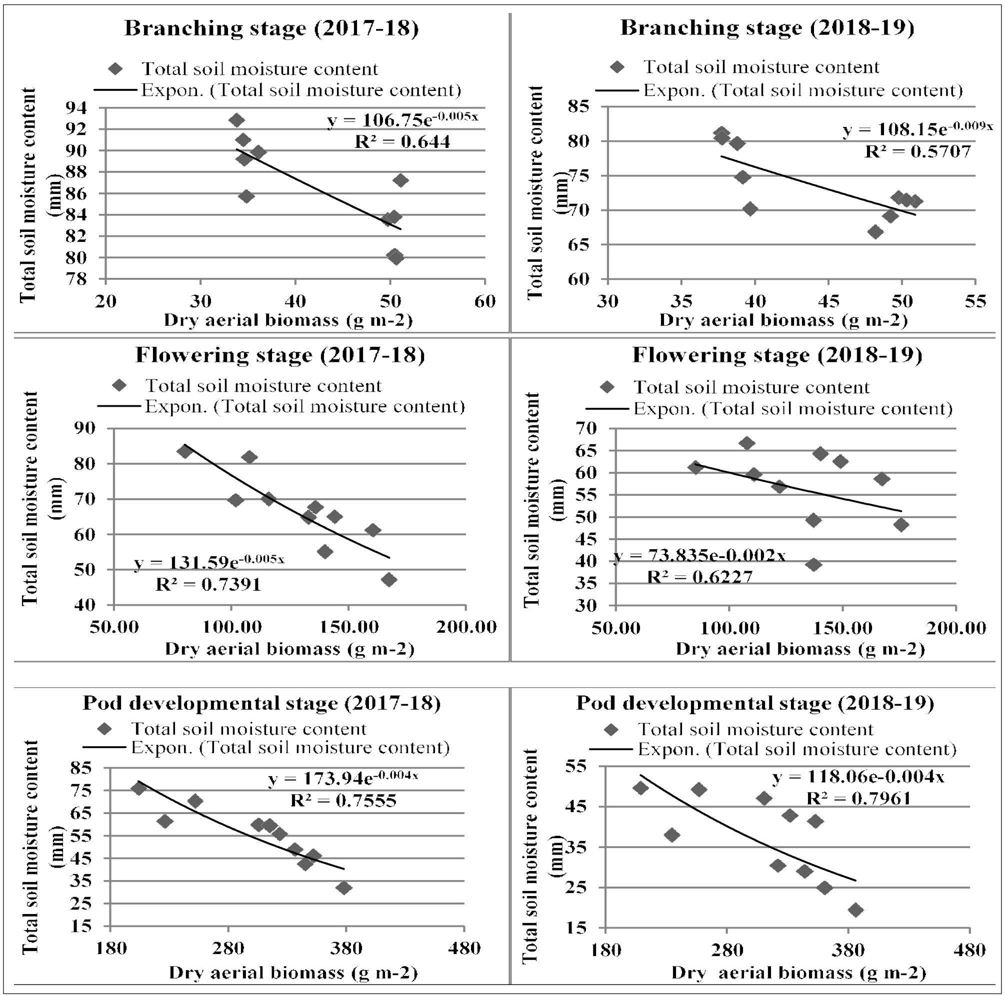

Fig 3: Response of total soil moisture content to dry aerial biomass of grass pea at different growth stages during 2017-18 and 2018-19.

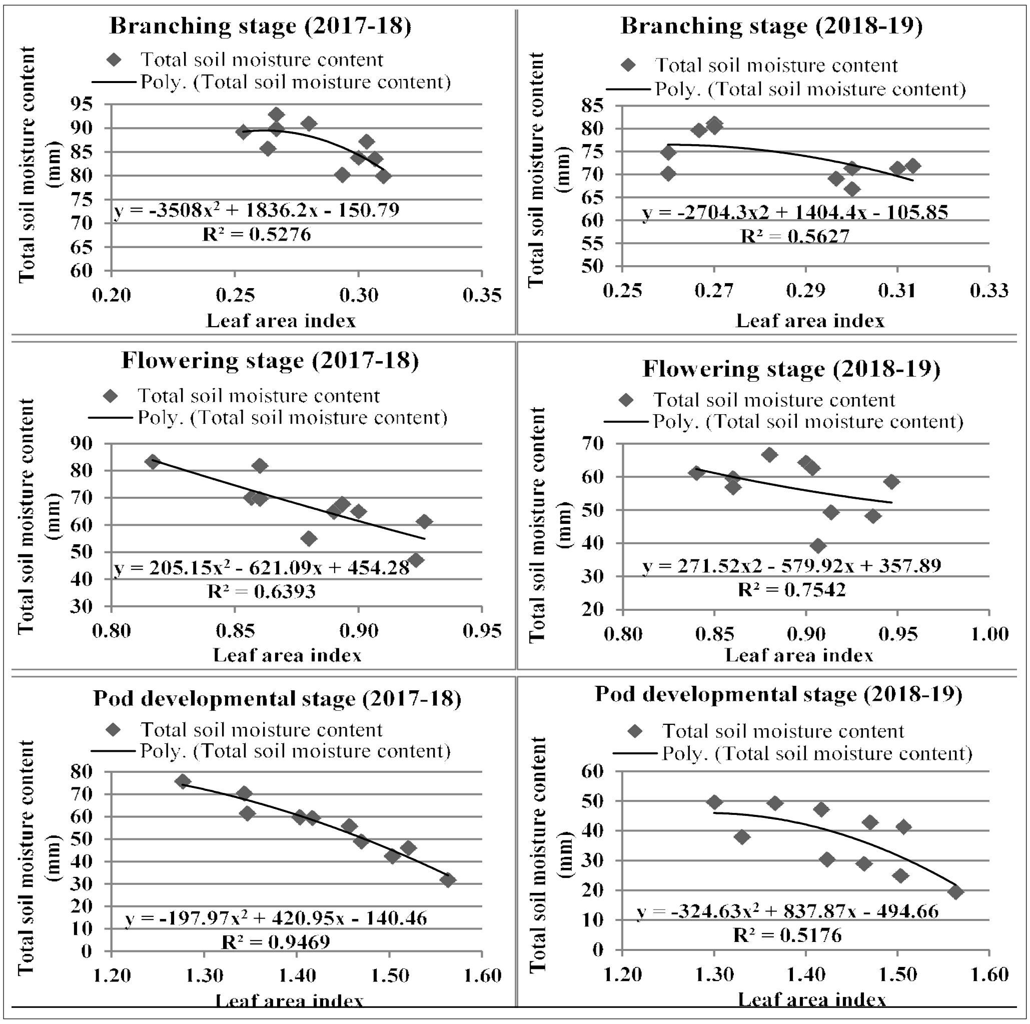

Fig 4: Relation between leaf area index and total soil moisture content at different growth stages of grass pea during 2017-18 and 2018-19.

Table 3: Soil profile water contribution in grass pea at different depths of soil in relation to seed priming and different foliar sprays of nutrients.

Treatment	Soil profile water contribution (mm)							
	2017-18				2018-19			
	0-15 cm	15-30 cm	30-45 cm	Total	0-15 cm	15-30 cm	30-45 cm	Total
S_1F_1	37.69	31.41	25.28	94.37	27.62	28.41	27.43	83.46
S_1F_2	38.51	32.23	25.89	96.64	29.57	29.74	29.01	88.31
S_1F_3	39.53	33.69	27.62	100.84	29.94	30.51	29.72	90.17
S_1F_4	39.43	35.14	31.41	105.98	31.41	31.91	32.01	95.33
S_1F_5	39.75	35.23	31.95	106.93	32.31	33.26	32.51	98.08
S_2F_1	38.14	33.77	27.64	99.54	29.7	29.78	28.65	88.13
S_2F_2	39.17	33.81	28.59	102.75	31.24	30.79	29.66	91.69
S_2F_3	40.31	34.99	29.96	104.08	31.69	31.63	30.62	93.94
S_2F_4	40.86	35.04	28.84	104.74	32.04	32.85	31.35	96.24
S_2F_5	42.28	35.78	30.38	108.43	33.17	33.28	33.21	99.66
S.Em(±)	0.89	0.51	0.78	0.52	0.67	0.44	0.65	14.67
C.D. (P=0.05)	NS	NS	2.33	1.57	NS	NS	NS	NS

*S_1- No seed priming; S_2- Seed priming with Amm. molyb. @ 0.5 g/ kg seed;

F_1- No foliar spray; F_2- 2% Urea (once); F_3- 2% Urea (twice); F_4- 0.5% NPK 19:19:19 (once); F_5- 0.5% NPK 19:19:19 (twice).

be polynomially correlated with total soil moisture content (Fig 4).

Profile water contribution of *Lathyrus*

Distinctive profile water contribution from soil reserve was zrecognized in different soil layers with respect to Lathyrus cultivation during *rabi* seasons of 2017-18 and 2018-19 in new alluvial soils of West Bengal (Fig 5 and Fig 6). Among the different treatment combinations, S_2F_5 received the highest-profile contribution during both the experimental years (Table 3).

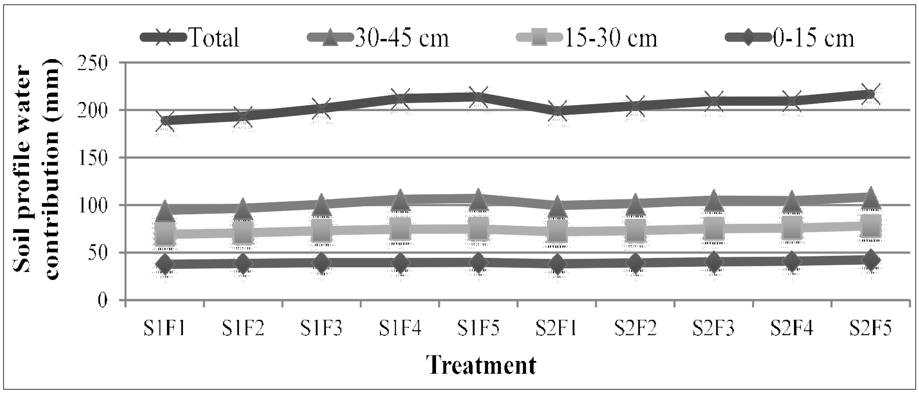

Fig 5: Profile water contribution at different depths of soil of grass pea during 2017-18.

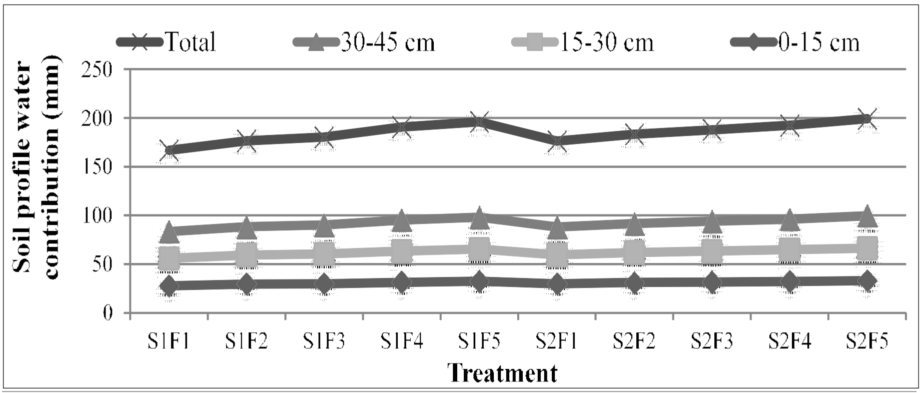

Fig 6: Profile water contribution at different depths of soil of grass pea during 2018-19.

Table 4: Yield, consumptive use of water and water use efficiency of grass pea as influenced by seed priming and different foliar sprays of nutrients.

Treatment	2017-18				2018-19			
	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Consumptive use (mm)	WUE (kg ha^{-1} mm^{-1})	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Consumptive use (mm)	WUE (kg ha^{-1} mm^{-1})
S_1F_1	1200.05	2644.79	103.77	11.56	1164.00	2495.79	98.57	11.81
S_1F_2	1343.99	2790.38	106.04	12.67	1258.30	2608.30	100.84	12.48
S_1F_3	1400.13	2847.03	110.24	12.70	1373.00	2690.86	105.04	13.07
S_1F_4	1480.94	3032.55	115.38	12.84	1319.55	2649.81	110.18	11.98
S_1F_5	1562.00	3137.09	116.33	13.43	1402.17	2703.50	111.13	12.62
S_2F_1	1333.00	2840.26	108.94	12.24	1243.80	2572.89	103.74	11.99
S_2F_2	1487.00	2983.94	112.15	13.26	1404.67	2686.02	106.95	13.13
S_2F_3	1549.03	3044.01	113.48	13.65	1483.00	2749.74	108.28	13.70
S_2F_4	1637.97	3247.35	114.14	14.35	1558.00	2922.36	108.94	14.30
S_2F_5	1726.73	3351.66	117.83	14.65	1666.67	2996.42	112.63	14.80
S.Em(±)	60.10	13.29	0.52	0.35	4.61	20.58	0.52	0.39
C.D. (P=0.05)	180.00	NS	1.56	NS	13.82	61.61	1.57	1.18

*S_1- No seed priming; S_2- Seed priming with Amm. molyb. @ 0.5 g/kg seed;

F_1- No foliar spray; F_2- 2% Urea (once); F_3- 2% Urea (twice); F_4- 0.5% NPK 19:19:19 (once); F_5- 0.5% NPK 19:19:19 (twice).

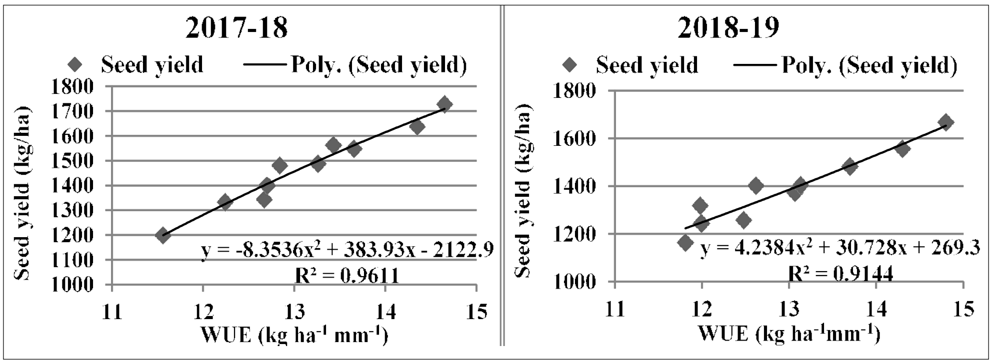

Fig 7: Relation between water use efficiency and seed yield of grass pea during 2017-18 and 2018-19.

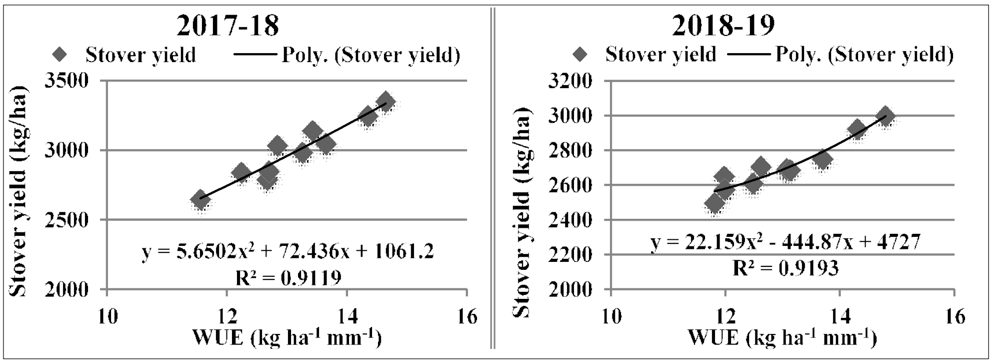

Fig 8: Relation between water use efficiency and stover yield of grass pea during 2017-18 and 2018-19.

Seasonal consumptive use of water

The seasonal consumptive use of water by grass pea was influenced by only profile contribution and precipitation in the form of rainfall as no external irrigation was provided. Due to high rainfall during 1st year, the seasonal consumptive use of water was higher as compared to the subsequent year. The maximum seasonal consumptive use was recorded with the S_2F_5 (117.83 mm and 112.63 mm) during 2017-18 and 2018-19 respectively (Table 4).

Water use efficiency (WUE) of *Lathyrus*

Highest water use efficiency was achieved with S_2F_5 treatment (16.65 and 14.80 kg ha^{-1} mm^{-1}) during 2017-18 and 2018-19 respectively (Table 4). Performance of grass pea in terms of yield under S_2F_5 treatment was best among all the treatment combinations due to maximum utilization of residual soil moisture during all phenological stages. Maximum improvement in WUE under treatment S_2F_5 maybe because of the higher yield as a result of the balanced nutrition combined with reduced loss of water due to the stomatal closure and falling rate of transpiration as supported by the work of Fahad *et al.* (2017).

Water use efficiency was polynomially correlated with seed yield and stover yield of grass pea in both the years (Fig 7 and 8). About 96.11 and 91.44% variations in seed yield could be contributed to the variation in WUE of grass pea in the respective years. Likewise, variations in stover yield were 91.19 and 91.13% which could be attributed to the variation in WUE during the two years.

Many researchers have reported that fertilization with K had a significant role in plants to alleviate the effect of the moisture shortage through improved WUE along with lower leaf ET (Sardans *et al.*, 2012; Grzebisz *et al.*, 2013 and Hasanuzzaman *et al.*, 2018). K broadly maintains cellular osmo-regulation, which helps in balancing the turgor and expansion of cells (Yadav *et al.*, 2019). This whole process is required for root and shoot expansion. Kinds of literature has established the role of K in regulating the water economy of plants and thus optimizing WUE (Egilla *et al.*, 2005; Kanai *et al.*, 2011, Majeed *et al.*, 2016). However, poor seed yield owing to moisture deficit could be overcome through increment of K supply (Danial *et al.*, 2010; Taia *et al.*, 2016).

CONCLUSION

The combination of seed priming with Ammonium molybdate @ 0.5 g kg^{-1} seed along with a foliar spray of 0.5% NPK (19:19:19) at the pre-flowering stage and 15 days after the 1st spray may be recommended as a profitable technology for efficient production with better water use efficiency of relay grass pea in new alluvial zone of West Bengal.

Conflict of interest: None.

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