

Effect of irrigation intervals and antitranspirants application on the yield and nutrient uptake by blackgram

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ABSTRACT: Water stress is the wide spread hydro metrological syndrome of prolonged period of water scarcity, which severely affect agricultural productivity. Water stress induced changes are mainly related to metabolic functions, such as reduced synthesis of photosynthetic pigments, accumulation of osmoprotectants like proline in the cell and decline in the cell membrane stability. In order to minimize the effect of water stress, the antitranspirants are applied as foliar spray. The present investigation was carried out to find the effect of irrigation interval and foliar application of different antitranspirants on nutrient uptake and yield of black gram (vigna mungo). A field experiment was conducted during March-May 2017. The treatments consisted of three irrigation interval viz., 5 DAI (Days after irrigation), 10 DAI and 15 DAI and eight treatments of foliar applications [T_1 - control, T_2 - PPFM (pink pigmented facultative methalotrophs), T_3 - salicylic acid, T_4 - miracle gold, T_5 - green gold, T_6 - ATP 67 @ 0.3%, T_7 - ATP 67 @ 0.5%, T_8 - ATP 68 @ 0.3%, and T_9 - ATP 68 @ 0.5%]. The results of the study revealed that increase in the irrigation interval consistently decreased the nutrient uptake and yield of blackgram. Application of antitranspirants to the blackgram reduced the impact of water stress in respect of yield and nutrient uptake by seed and haulm. Foliar application of ATP 67 @ 0.3% to plants irrigated at 5 DAI, (I_1T_6) recorded significantly highest values in yield attributes viz., number of pods per plant (23.17), number of seeds per pod (6.02), seed yield (1235 kg ha⁻¹) and haulm yield (2295.33 kg ha⁻¹) as compared to other treatments. The uptake of nutrient was also affected due to water stress. Increased moisture content in soil enhanced the uptake of NPK by seed and haulm. The treatment I_1T_6 (5 DAI + ATP 67 @ 0.3% foliar spray) recorded the highest NPK uptake of 39.47 kg ha⁻¹, 6.58 kg ha⁻¹, 23.17 kg ha⁻¹ by seed and 56.6 kg ha⁻¹, 5.51 kg ha⁻¹, 39.52 kg ha⁻¹ by haulm respectively. This was followed by I_1T_7 (5 DAI + ATP 67 @ 0.5%). The result of the study also showed that application of antitranspirants (ATP 67 @ 0.3%) to plants irrigated at 10 DAI (I_2T_6) produced comparable yield as that of the plant irrigated at 5 DAI without ant antitranspirant spray (I_1T_1).

1.1. INTRODUCTION

Pulses are commonly known as food legumes which are next to cereals in production and consumption in India. Pulses provide 25 per cent of protein requirement of predominantly vegetarian population in India. Black gram (*Vigna mungo* L.) is the third important pulse crop of India and it is native to central Asia. It becomes popular because of its nutritional quality. It is rich protein (26.2%), carbohydrates (56.6%), fat (1.2%), mineral (potassium, phosphorus, calcium and sodium) and vitamins (A1, B1, B3). It also has some medicinal properties and used in the treatment of diabetes, nervous disorders, digestive system disorders and rheumatic affliction (Anonymous, 2010). In India, black gram is cultivated in an area of 33.33 lakh hectares with a total production of 18.86 lakh tonnes and productivity of 461 kg ha⁻¹ (Tiwari and Shivhare, 2016). Black gram productivity is greatly influenced by various environmental factors such as temperature, light, water and nutrient availability. Soil moisture stress is a kind of abiotic stress which cause considerable reductions in the productivity of black gram. Around 30-40% decline in grain yield of blackgram was documented under mid water stress, even without harvest under extremely water stress condition (Manoj Katiyar and Amit Kumar, 2015). Water stress reduces nutrient uptake by the roots, in part, because the decline in soil moisture results in a decreased rate of diffusion of nutrients from the soil matrix to the absorbing root surface (Waraich *et al.*, 2011). Therefore, it is essential to balance, water consumption and yield of crops for effective utilization of water. Nearly 95 percent of the water absorbed by the plant is lost in transpiration. The application of antitranspirants, decreases the water loss from plant leaves by reducing the size and number of stomata. The principle of transpiration control is by increasing leaf resistance to water vapour transfer by application of materials which tend to close or cover stomata (both stomatal closing and film forming type of antitranspirant), by reducing amount of energy absorbed by leaf surface (leaf reflectants), by reducing top growth of plants (growth retardants), by increasing air resistance to water vapour transfer, by shelter belts or wind breaks. Transpiration suppressants was advantageous under deficit irrigation situations to increase yield significantly (Myaka *et al.*, 2006). Application of antitranspirants like Fatty alcohol, Pink Pigmented Facultative Methylotrophs (PPFM) and salicylic acid also increase the yield and nutrient uptake of black gram under water stress condition. The long chain fatty alcohol reduces transpiration rate and facilitates to maintain the cell turgor under water stress condition thereby helps in conserving the water inside the leaf tissue and protect plants from desiccation to some extent (Patil satish 2016). The present study was undertaken to establish the effect of irrigation intervals and foliar application of antitranspirants on the growth, yield and nutrient uptake by black gram.

2.1. Materials and methods

A field experiment was conducted at a farmer's field at Sivapuri village, Chidambaram taluk, Cuddalore district, Tamilnadu. The experimental soil (Typic haplustalf) was clay loam in texture, neutral in reaction (pH 7.3), medium in organic carbon (6.6 g kg⁻¹), low in available N (272 kg ha⁻¹), high in available P (23 kg ha⁻¹) and medium in available K (174 kg ha⁻¹). The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications. The treatments consisted of three irrigation intervals viz. 5 DAI (I_1), 10 DAI (I_2) and 15 DAI (I_3) and eight treatments of antitranspirants application. The details of the treatment were T_1 -Control, T_2 -PPFM, T_3 - Salicylic acid, T_4 - Miracle Gold, T_5 - Green Gold, T_6 -ATP 67 @ 0.3%, T_7 - ATP 67 @ 0.5%, T_8 - ATP 68 @ 0.3%, T_9 - ATP 68 @ 0.5%. A uniform fertilizer dose of 25 kg N, 50 kg P₂O₅ and 25 kg K₂O was applied to all the plots through urea, single super phosphate and muriate of potash respectively. Black gram var.vemban 4 (bg) was grown as test crop. Each treatment was replicated thrice. The antitranspirants ATP 67 and ATP 68 was supplied by EID parry limited,

green gold was supplied by Ishvarya organics, miracle gold was obtained from stanes limited. All these antitranspirants contains fatty alcohol as their antitranspirant compound. PPFM (pink pigmented facultative methylotrophs) was obtained from department of microbiology, Annamalai university. Laboratory grade salicylic acid was used in the study. The antitranspirants were sprayed at 20 and 40 DAS. The yield parameters (number of pods per plant, number of seeds per pod and 100 seed weight) and yield of seed and haulm were recorded at appropriate stages. The seed and haulm samples obtained at harvest were analysed for total NPK content using standard methods.

DISCUSSION

Increase in the days to irrigation generally decreased the yield attributing characters namely number of pods per plant, number of seeds per pod and 100 seed weight as well as seed and haulm yield of blackgram. Irrespective of the antitranspirants spray, number of pods plant⁻¹, number of seeds per pod, 100 seed weight, seed and haulm yield were significantly decreased with increase in irrigation interval. Increase in the days to irrigation from 5 to 15 significantly decreased the number of pods per plant, number of seeds per pod, 100 seed weight, seed and haulm yield. Among the three irrigation intervals, 5 DAI recorded the highest mean number of pods per plant, number of seeds per pod, 100 seed weight, seed and haulm yield

Regardless of the irrigation interval, application of antitranspirants to black gram significantly improved the number of pods per plant. Among the antitranspirants the application of ATP 67 @ 0.3% (T₆) recorded the highest mean number of pods per plant, number of seeds per pod, 100 seed weight, seed and haulm yield.

A significant interaction was noticed between days to irrigation and antitranspirants application in increasing the number of pods per plant, number of seeds per pod, 100 seed weight, seed and haulm yield of black gram. Application of ATP 67 @ 0.3% to plants irrigated at 5 days interval recorded highest number of pods per plant (23.17), number of seeds per pod (6.02), 100 seed weight (3.65), seed (1235 kg ha⁻¹) and haulm yield (2295.33), which was followed by This was closely followed by application of antitranspirant of ATP67 @ 0.5% + 5DAI (I₁T₇), Which recorded the number of pods per plant (22.56), number of seeds per plant (5.98), seed yield (1198.67 kg ha⁻¹) and haulm yield (2218.67 kg ha⁻¹). However, the treatments I₁T₄, I₁T₂, I₁T₃ and I₁T₁ were found to be an on par to each other. The lowest number of pods per plant, number of seeds per pod, 100 seed weight, seed and haulm yield were noticed in the treatments irrigated at 15 days interval without any antitranspirant spray (I₃T₁).

The result of the study clearly showed that increase in the days to irrigation significantly reduced the number of pods per plant, number of seeds per pod, 100 seed weight, seed and haulm yield of Black gram. The foliar application of commercial formulations green gold (T₅) and miracle gold (T₄) also significantly increased the number of pods per plant, number of seeds per pod, 100 seed weight, seed and haulm yield at all the three irrigation intervals. The Antitranspirants PPFM and salicylic acid also increase the yield attributing characters significantly.

Similar trend was observed with the uptake of NPK by seed and haulm. The highest NPK uptake of 39.47 kg ha⁻¹, 6.58 kg ha⁻¹, 23.17 kg ha⁻¹ by seed and 56.6 kg ha⁻¹, 5.51 kg ha⁻¹, 39.52 kg ha⁻¹ by haulm respectively, was noticed in the treatment irrigated at 5 days interval and sprayed with ATP 67 @ 0.3%.

The variations in yield due to treatments could be attributed to the variations in the yield attributing parameters. The main yield attributes in blackgram are number of pods per plant, number of seeds per pod and 100 seed weight. The difference in the performance of yield attributes in various treatments could be due to variation in irrigation intervals and antitranspirants application. Water stress at grain development reduces yield while vegetative and grain filling stages are sensitive to moisture stress (Borrell et al., 2006). The yields of the blackgram were found to decrease at pre-anthesis water stress (Baroowa and Gogoi 2012). Foliar application of antitranspirant increased the yield attributes of blackgram by reducing transpiration loss from vegetative parts. Fatty alcohol is a bio film forming type which reduces transpiration rate under water deficit and there by helps to maintain more water in leaves, enhance the bio chemical activities like photo synthesis and improved the yield and yield attributes of blackgram (Patil satish et al., 2016).

Water stress greatly impacts the nutrient relations of the plants. Many important nutrients including nitrogen are taken up by roots along with water, the water stress conditions limit the movement of these nutrients via diffusion and mass which leads to retarded plant growth (Barber, 1995). The response to the mineral uptake under moisture stress varies across the crop species. In general, N uptake is increased, P uptake is declined and potassium remains unaffected under water stress conditions. But, over all water stress reduced the uptake of N, P, K, Ca, Mg and S (Kolay, 2008). The result of the study showed that nutrient uptake viz., Nitrogen, phosphorus and potassium were significantly influenced by irrigation interval antitranspirant spray.

The N, P and K uptake was significantly influenced by the irrigation intervals, antitranspirant spray and their interaction. Increase in the days to irrigation from 5 to 15 significantly decreased the N, P and K uptake by seed and haulm of blackgram. Application of antitranspirant to blackgram significantly increase the N, P and K uptake by seed and haulm at all irrigation intervals. Foliar application of fatty alcohol containing formulations protect the plant under water stress condition and reduce the transpiration losses and facilitates maintenance of cell turgor, thereby increase the uptake of N, P and K by blackgram (Prime et al., 2012).

From the results of the study it is concluded that increase in the days to irrigation 5 to 15 significantly reduced the yield and nutrient uptake by black gram. Irrigation at 5 days interval and foliar application of antitranspirant ATP 67 @ 0.3% was established as the best treatment combination to improve the growth and yield of black gram. However, foliar application of antitranspirants ATP 67 @ 0.3% is recommended to black gram to escape from moisture stress and to avoid yield loss, when the irrigation interval is prolonged from 5 to 10 days.

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Result

Table 1. Effect of irrigation Intervals and antitranspirants application on number pods per plant of black gram

Irrigation Interval Treatment	Irrigation Interval			MEAN
	5 DAI	10 DAI	15 DAI	
T ₁	17.18	16.80	16.55	16.84
T ₂	18.00	17.60	17.68	17.56
T ₃	17.59	16.84	16.93	17.12
T ₄	18.58	18.07	17.60	18.08
T ₅	19.53	18.36	17.82	18.57
T ₆	23.17	20.84	18.49	20.83
T ₇	22.56	20.10	18.47	20.38
T ₈	21.00	19.28	18.34	19.54
T ₉	20.20	18.91	17.85	18.90
MEAN	19.76	18.53	17.68	18.66

	SED	CD(0.05)
I	0.18	0.36
T	0.31	0.62
IT	0.53	1.07

Table 2. Effect of irrigation Intervals and antitranspirants application on seeds per pod of black gram

Irrigation Interval Treatment	5 DAI	10 DAI	15 DAI	MEAN
T ₁	5.29	4.29	3.12	4.24
T ₂	5.41	4.54	3.39	4.45
T ₃	5.29	4.43	3.27	4.33
T ₄	5.54	4.76	3.52	4.61
T ₅	5.68	4.84	3.63	4.72
T ₆	6.02	5.28	4.19	5.16
T ₇	5.98	5.17	3.92	5.02
T ₈	5.90	5.04	3.87	4.94
T ₉	5.77	4.97	3.74	4.83
MEAN	5.65	4.81	3.63	4.71

	SED	CD(0.05)
I	0.039	0.078
T	0.677	0.136
IT	0.117	0.235

Table 3. Effect of irrigation Intervals and antitranspirants application on hundred seed weight of black gram(g)

Irrigation Interval Treatment	5 DAI	10 DAI	15 DAI	MEAN
T ₁	3.49	3.31	3.18	3.33
T ₂	3.52	3.41	3.22	3.39

T ₃	3.5	3.39	3.2	3.36
T ₄	3.54	3.45	3.24	3.41
T ₅	3.56	3.48	3.27	3.44
T ₆	3.65	3.57	3.39	3.54
T ₇	3.62	3.55	3.36	3.51
T ₈	3.61	3.52	3.34	3.49
T ₉	3.58	3.5	3.29	3.46
MEAN	3.56	3.47	3.28	3.44

	SED	CD(0.05)
I	0.028	0.056
T	0.048	0.097
IT	0.084	0.168

Table 4. Effect of irrigation Intervals and antitranspirants application on seed yield of black gram (Kgha⁻¹)

Irrigation Interval Treatment	5 DAI	10 DAI	15 DAI	MEAN
	T ₁	944.33	805.33	627.33
T ₂	990.33	867.38	728.47	862.04
T ₃	970.33	848.33	683.33	834
T ₄	1030.67	909.33	798.53	912.84
T ₅	1098.33	937.33	835.77	957.14
T ₆	1235	1105.33	979.33	1106.56

T ₇	1198.67	1013.97	937.73	1049.8
T ₈	1167.67	973	912.4	1017.69
T ₉	1111.33	957.67	863.8	977.6
MEAN	1082.96	935.19	818.52	945.56

	SED	CD(0.05)
I	11.48	22.04
T	19.88	39.91
IT	34.44	69.12

Table 5. Effect of irrigation Intervals and antitranspirants application on haulm yield of black gram(Kgha⁻¹)

Irrigation Interval Treatment	5 DAI	10 DAI	15 DAI	MEAN
	T ₁	1910.67	1422.00	1122.00
T ₂	1985.33	1686.67	1509.00	1727.11
T ₃	1951.33	1657.33	1474.67	1694.44
T ₄	2090.67	1698.00	1581.67	1790.11
T ₅	2095.67	1774.00	1632.00	1833.89
T ₆	2295.33	1987.67	1791.00	2024.67
T ₇	2218.67	1914.00	1718.67	1950.44
T ₈	2196.00	1894.00	1689.67	1926.56
T ₉	2112.33	1850.00	1648.67	1870.33
MEAN	2095.11	1764.85	1574.15	1811.38

	SED	CD(0.05)
I	43.33	86.95
T	75.05	150.61
IT	130.1	260.86

Table 6. Effect of irrigation Intervals and antitranspirants application on N uptake by seed (Kgha⁻¹)

Irrigation Interval Treatment	5 DAI	10 DAI	15 DAI	MEAN
	T ₁	24.71	17.04	11.37
T ₂	29.40	19.67	12.73	20.60
T ₃	27.59	18.09	12.24	19.30
T ₄	31.37	21.00	13.41	21.92
T ₅	33.04	22.09	14.71	23.28
T ₆	39.47	29.62	20.06	29.72
T ₇	38.09	28.04	19.09	28.41
T ₈	36.82	25.59	17.48	26.63
T ₉	34.59	23.45	15.81	24.61
MEAN	32.79	22.73	15.21	23.58

	SED	CD(0.05)
I	0.267	0.535
T	0.462	0.927
IT	0.800	1.606

Table 7. Effect of irrigation Intervals and antitranspirants application on P uptake by seed (Kgha^{-1})

Irrigation Interval Treatment	5 DAI	10 DAI	15 DAI	MEAN
	T1	5.41	4.82	4.11
T2	5.65	5.03	4.33	5.00
T3	5.56	4.91	4.22	4.91
T4	5.78	5.27	4.42	5.16
T5	6.10	5.32	4.50	5.31
T6	6.58	5.76	4.1	5.75
T7	6.43	5.61	4.82	5.62
T8	6.38	5.53	4.76	5.56
T9	6.26	5.41	4.62	5.43
MEAN	6.02	5.31	4.52	
	SED	CD(0.05)		
I	0.017	0.033		
T	0.029	0.057		
IT	0.050	0.099		

Table 8. Effect of irrigation Intervals and antitranspirants application on K uptake by black gram (Kg ha^{-1})

Irrigation Interval Treatment	5 DAI	10 DAI	15 DAI	MEAN
	T ₁	16.95	16.97	16.72
T ₂	18.12	17.36	17.25	17.58

T ₃	17.70	16.95	16.70	17.12
T ₄	18.71	18.19	17.37	18.09
T ₅	19.26	18.49	17.94	18.56
T ₆	23.17	20.56	18.88	20.87
T ₇	22.70	20.10	18.61	20.47
T ₈	21.07	19.41	18.10	19.53
T ₉	20.40	18.98	17.97	19.12
MEAN	19.79	18.56	17.73	18.69

	SED	CD(0.05)
I	0.142	0.284
T	0.246	0.493
IT	0.425	0.853

Table 9. Effect of irrigation Intervals and antitranspirants application on N uptake by haulm (Kgha⁻¹)

Irrigation Interval Treatment	5 DAI	10 DAI	15 DAI	MEAN
	T ₁	50.4	36.2	25.4
T ₂	52.4	38.9	26.9	39.41
T ₃	51.5	37.5	26.3	38.44
T ₄	53.2	40.1	27.5	40.27
T ₅	53.7	41.5	28.2	41.13
T ₆	56.6	45.8	30.6	44.33

T ₇	56.1	44.7	29.8	43.53
T ₈	55.5	43.4	29.1	42.67
T ₉	54.2	42.3	28.7	41.73
MEAN	53.73	41.16	28.06	

	SED	CD(0.05)
I	0.132	0.264
T	0.228	0.458
IT	0.395	0.793

Table10. Effect of irrigation Intervals and antitranspirants application on P uptake by haulm (Kg ha⁻¹)

Irrigation Interval Treatment	Irrigation Interval			MEAN
	5 DAI	10 DAI	15 DAI	
T ₁	4.68	3.81	2.76	3.75
T ₂	4.87	4.02	3.13	4.01
T ₃	4.75	3.90	3.03	3.89
T ₄	5.02	4.17	3.21	4.13
T ₅	5.17	4.21	3.32	4.23
T ₆	5.51	4.66	3.87	4.68
T ₇	5.44	4.56	3.76	4.59
T ₈	5.32	4.47	3.67	4.49
T ₉	5.28	4.32	3.41	4.34
MEAN	5.12	4.24	3.35	

	SED	CD(0.05)
I	0.014	0.027
T	0.024	0.047
IT	0.041	0.082

Table11. Effect of irrigation Intervals and antitranspirants application on K uptake by haulm (Kg ha^{-1})

Irrigation Interval Treatment	5 DAI	10 DAI	15 DAI	MEAN
	T ₁	30.89	22.32	15.32
T ₂	32.61	24.12	17.55	24.76
T ₃	31.77	23.24	16.45	23.82
T ₄	33.55	25.32	18.64	25.84
T ₅	34.17	26.44	19.57	26.73
T ₆	39.52	30.92	23.41	31.28
T ₇	38.41	29.77	22.24	30.14
T ₈	37.54	28.66	21.52	29.24
T ₉	35.24	27.55	20.64	27.81
MEAN	34.86	26.48	19.48	

	SED	CD(0.05)
I	0.087	0.174
T	0.150	0.301
IT	0.260	0.522