Short communication

Water stress mitigation in vegetable cowpea through seed hardening and moisture conservation practices

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Abstract

A field experiment was conducted at the College of Horticulture, Vellanikkara during summer season of 2014 (January - March) to study the potential benefits of seed hardening, antitranspirant spray and mulching for mitigating water stress in vegetable cowpea variety *Kashi kanchan*. Pod yield, stover yield as well as dry matter production were highest in plots irrigated at 2 days interval (farmer's practice) followed by those irrigated at 5 days interval. Among treatments, plastic mulching recorded the highest pod yield (2.3 Mg ha^{-1}) which was on par with plant residue mulching (2.1 Mg ha^{-1}). Moreover, mulching resulted in an increased yield of 162-182% over control. Among the seed primers, 0.5% NaCl, and among the antitranspirants, lime water spray recorded the highest pod yield of 1.9 Mg ha^{-1} and 1.5 Mg ha^{-1}respectively.

Key words: Seed priming, Antitranspirants, Mulches, Water stress, Moisture conservation

Vegetable cowpea is an important protein catering vegetable, largely consumed in the state. Being a non-season bound crop, it can be grown throughout the year. Even though the crop performs well during summer season under irrigation, water scarcity limits its area under cultivation. It necessitates the development of alternate management technologies to overcome the water stress period for the sustainable growth and yield of the crop. Seed hardening is one technique which helps the plant to survive under drought. Seed hardening with $CaCl_2$ increased the yield of chickpea (Manjunath and Dhanoji, 2011). Antitranspirant spray and soil moisture conservation measures like mulching helps to reduce evapotranspiraton and thereby conserve moisture in plant and soil. Kaolin spray (8%) along with mulching with plastic film recorded highest yield attributes in groundnut (Chitodkar et al., 2005). However studies in this line in Kerala are meagre. So the present study was undertaken to evaluate the efficacy of various seed primers, antitranspirants and mulches for mitigating water stress in vegetable cowpea grown during summer season, to find out the best among each and also to assess the response of vegetable cowpea to these techniques under water stress conditions.

A field experiment was conducted during summer season of 2014 (January - March) in Agronomy farm, College of Horticulture, Vellanikkara ($10^0$31' N latitude and $76^0$13'E longitude) in Thrissur district of Kerala, India using the vegetable cowpea variety *Kashi Kanchan* (variety released from Indian Institute of Vegetable Research, Varanasi). It is a short duration (65-70days), photo-insensitive, dwarf and bush type vegetable cowpea variety with dark green, soft, fleshy pods, which performs very well under Kerala conditions. The soil of the experimental site was sandy clay loam having a bulk density of 1.58 Mg m^{-3}, pH 5.4, organic carbon 1.2%, available phosphorus and potassium 31.9 and 378.8 kg ha^{-1} respectively. The experiment was laid out in Randomized Block Design with 11 treatments and 3 replications in mini plots of size 1.5m x1.5m. The treatments comprised of three seed primers namely 2% $CaCl_2$, 0.5% NaCl and 1% KH_2PO_4, two

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types of mulching namely plastic mulching (PM) and plant residue mulching (PRM) and three antitranspirants like kaolin 2%, lime water 2% (LWS), and atrazine 0.1 kg ha^{-1} which were compared with farmers' practice (irrigation at 2 days interval), irrigation at 5 days interval and irrigation at 5 days interval with no irrigation during stress imposed period. Seed priming was done by soaking the seeds in solutions of 2% $CaCl_2$, 0.5% NaCl and 1% KH_2PO_4 for four hours and drying under shade. Plastic mulching was done with polythene mulch having silver colour on the top and black colour on the bottom. Plant residue mulching was done with cut grass to a thickness of 2.5 inches. Anti-transpirants were sprayed on the plants with a spray fluid volume of 500L ha^{-1}.

Cowpea seeds were dibbled at a spacing of 30cm x 30cm on 3rd January. The experimental plots were irrigated daily upto 5 DAS for uniform germination of seeds. Thereafter, the plots sown with primed seeds and mulched were irrigated at 10 days interval and plots sprayed with antitranspirants were irrigated at 5 days interval upto 15 DAS, skipping irrigation at 20, 25, 30 and 35 DAS to impose water stress. Irrigation water was quantified and was given at 2cm depth with hose. Both mulches were laid on the field on 5th day after sowing, immediately after irrigation. Antitranspirants were sprayed at 25 DAS (10 days after imposing water stress). Observations on biometric characters, yield attributes and physiological parameters were recorded 35 days after sowing (10 days after spraying anti-transpirants) from randomly selected plants. Plant height was measured in cm from ground level to the tip of growing point at 15 days interval upto 60 DAS and the mean was worked out. Fully opened leaves and branches were counted at 15 days interval upto 60 DAS and the mean was worked out. Leaf chlorophyll content was estimated by following the procedure of Arnon (1949) and Kirch (1968). Relative leaf water content was calculated using the following equation (Barrs, 1986):

Soil samples were taken at 0-20cm depth using auger and the moisture content was estimated (at sowing and at 15 days interval till 60 DAS) by thermo-gravimetric method. Field water use efficiency (FWUE) was calculated as the ratio of pod yield per plot to the total quantity of water applied to the plot. The prevailing labour charge in the locality and cost of inputs were considered for computing gross expenditure and expressed in rupees per hectare. The yield of vegetable cowpea and its prevailing local market price (Rs.35 kg^{-1}) were considered for computing gross return and expressed in rupees per hectare.

General growth and yield of the crop was less than normal due to the absence of rainfall and extreme dry condition which prevailed during the entire crop growth period (Table 1). Growth parameters presented in Table 2 showed that plant height (at 15 and 45 DAS), number of leaves (at 45 DAS), number of branches (at 60 DAS) and root length were significantly influenced by treatments. Application of various treatments resulted in an increasing trend of plant height from 2 to 21 %, and number of leaves from 15 to 67 % compared to that which received no treatment during the crop period. Tallest plants with highest number of leaves were observed in plots which received irrigation on alternate days (Farmer's practice) due to non-exposure of plants to water stress. However, plant height in plots irrigated on alternate days (Farmer's practice) was found to be on par with the treatments

Table 1. Monthly mean climatological data during the crop period

Month	Maximum temperature (^{0}c)	Minimum temperature (^{0}c)	RH (%) morning	RH (%) evening	Rainfall (mm)	Total evaporation (mm)	Sunshine hours	Wind speed (Km hr^{-1})
January	32.9	23.0	66	36	0	171.3	277.6	6.9
February	34.7	22.9	75	37	0	145.0	240.8	4.5
March	36.7	24.2	76	34	0	191.5	264.2	3.9

Table 2. Effect of treatments on growth parameters of crop

Treatment	Plant height (cm)		No. of leaves		No. of branches			Root	Days to
	15 DAS	45 DAS	15 DAS	45 DAS	30 DAS	45 DAS	60 DAS	length (cm)	flowering
Seed priming $CaCl_2$	5.6	7.7	3.1	7.5	0.1	0.5	2.0	14.7	46.3
Seed priming Nacl	5.3	7.2	3.1	7.9	0	1.3	3.3	15.2	47.3
Seed priming KH_2PO_4	5.7	7.5	3.2	6.4	0	1.0	2.5	15.0	45.6
PM	5.6	7.7	3.2	7.8	0.3	1.1	2.3	15.2	48.7
PRM	6.9	8.3	3.0	6.7	0	0.4	2.1	15.0	48.7
Kaolin	5.6	7.0	3.1	6.8	0	0.1	1.3	14.5	49.0
LWS	5.9	7.4	3.2	8.6	0.06	0.5	2.5	15.0	48.7
Atrazine	5.9	6.8	3.0	6.3	0	0.1	1.3	13.3	49.0
Control(Irri. 5 days)	5.5	7.6	3.1	10.7	0	1.0	2.3	15.3	45.3
Farmer's practice (Irri. 2 days)	5.5	8.4	3.1	12.3	0	2.1	3.7	15.6	45.0
Control (Irri.5 days with imposed water stress)	5.7	6.5	3.0	6.0	0	0.1	1.3	11.1	49.0
CD(0.05)	0.61	1.12	NS	2.42	NS	NS	0.82	2.06	NS

seed hardening either with $CaCl_2$, or NaCl, or KH_2PO_4, mulching with either polythene or plant residue, spraying lime water as antitranspirant during water stress period. Shortest plants with lowest number of leaves were observed in plots which were irrigated at 5 days interval with imposed water stress, due to the exposure of plants to water stress from 15 to 35 DAS. Moreover, plant height in this treatment was found to be significantly inferior to seed hardening with $CaCl_2$ and mulching either with polythene or plant residue. At 30 DAS, branch initiation was noted only in seed hardening with $CaCl_2$, polythene mulching and lime water sprayed plots. However, at 60DAS, more number of branches was noted in the treatment seed hardening with NaCl, mulching either with polythene or plant residue and lime water sprayed plots. Root length was also significantly higher in all treatments with imposed water stress compared to control. Water shortage forced the plants to increase the root length so as to extract more water from deeper layers of soil. All these showed the positive effect of seed hardening and moisture conservation measures like mulching and antitranspirant spray on the growth of cowpea plants grown under water stress situation.

All the water stress imposed treatments showed a slight delay in flowering (1 to 4 days) compared to control which received irrigation at 2 days and 5 days interval. This is due to the delay in attaining sufficient vegetative growth before flowering as a result of imposed water stress as reported by French (2012) in faba bean.

Table 3. Effect of treatments on yield and yield attributes of crop

Treatments	Pod No. plant^{-1}	Pod length (cm)	Seeds pod^{-1}	Pod weight (g)	Pod yield (kg ha^{-1})	Stover yield (kg ha^{-1})	DMP* (kg ha^{-1})
Seed priming $CaCl_2$	2.7	27.8	12.7	8.4	1444.44	2885.18	940.41
Seed priming Nacl	4.0	26.2	12.4	8.5	1951.85	3038.27	1177.77
Seedpriming KH_2PO_4	2.7	26.7	12.9	8.4	1451.85	2960.90	826.33
PM	3.2	26.7	13.1	8.3	2344.44	3553.08	1155.55
PRM	2.7	26.2	12.3	8.4	2177.77	3124.69	999.58
Kaolin	1.7	22.9	12.2	6.2	1177.77	1311.11	532.51
LWS	2.3	27.1	12.4	8.2	1503.70	2725.92	840.74
Atrazine	1.7	22.4	12.3	6.3	1207.40	1674.07	605.92
Control (Irri. 5 days)	4.0	26.6	14.8	8.9	3662.96	4422.22	1406.17
Farmer's practice (Irri. 2 days)	7.7	26.5	14.9	8.2	5111.11	6065.43	2471.19
Control (Irri. 5 days with imposed water stress)	2.0	21.6	11.3	4.8	833.33	1194.23	395.06
CD(0.05)	0.96	1.7	NS	0.66	351.9	495.8	172.5

*DMP- dry matter production

Data presented in Table 3 showed that all treatments except Kaolin spray (2%) recorded significantly higher pod yield, stover yield and dry matter production compared to control which was irrigated at 5 days interval with imposed water stress, as a result of improved growth characters and yield attributes. This showed the positive effect of seed hardening and soil moisture conservation measures like mulching and antitranspirants like lime water spray on the yield of cowpea plants grown under water stress situation. Among the seed primers, NaCl 0.5% recorded 34% higher pod yield than $CaCl_2$ and KH_2PO_4, which showed its better effect in hardening the plants to drought through improvement in RLWC and total chlorophyll content (Table 4) and its favourable influence on better translocation of assimilates to the economic part. Jisha and Puthur (2014) also noticed the improved drought stress tolerance potential of *Vigna radiata* with halopriming using NaCl. Mulching resulted in a higher yield (162-182% over control) and dry matter production compared to non mulched plots due to better soil moisture conservation (Table 5). However, there was no significant difference between plastic mulching and plant residue mulching at 30 and 45 DAS. Significant role of mulching on soil moisture conservation is well established. Sarolia and Bhardwaj (2012) have also reported that mulched plants grow and mature more uniformly than unmulched plants as mulching reduces evaporation, increases infiltration and thereby conserves soil moisture. Fruit yield, fruit size, plant dry matter, total leaf area and chlorophyll content of cucumber under the stressed treatments were improved by black polyethylene mulch (Kirnak and Demirtas, 2006). Among

Table 4. Effect of treatments on physiological parameters (35 DAS)

Treatments	RLWC * (%)	Total chlorophyll (mg g^{-1} plant)
Seed priming $CaCl_2$	22.6	0.17
Seed priming Nacl	33.9	0.20
Seed priming KH_2PO_4	31.5	0.14
PM	33.1	0.16
PRM	32.4	0.17
Kaolin	11.8	0.12
LWS	27.6	0.19
Atrazine	16.9	0.08
Control (Irri. 5 days)	31.1	0.19
Farmer's practice (Irri. 2 days)	35.6	0.21
Control (Irri.5 days with imposed water stress)	24.1	0.12
CD(0.05)	0.07	0.05

*RLWC- relative leaf water content

Table 5. Effect of treatments on soil moisture content

Treatments	Soil moisture content (%)			
	15 DAS	30 DAS	45 DAS	60 DAS
Seed priming $CaCl_2$	8.4	9.7	8.1	8.9
Seed priming Nacl	8.9	9.3	8.0	8.4
Seedpriming KH_2PO_4	8.9	9.7	8.9	8.2
PM	11.2	10.8	9.4	9.3
PRM	10.6	11.0	9.2	9.9
Kaolin	9.7	7.7	9.4	8.3
LWS	9.6	7.5	9.2	8.2
Atrazine	9.9	7.4	9.3	8.3
Control (Irri. 5 days)	9.5	11.5	10.4	9.3
Farmer's practice (Irri. 2 days)	12.3	13.5	12.5	10.8
Control (Irri. 5 days with imposed water stress)	9.3	6.3	8.9	8.5
CD(0.05)	0.537	0.463	0.545	0.523

antitranspirants, lime water spray exhibited a significant influence on dry matter production of cowpea compared to kaolin spray and atrazine spray. This is due to the effect of lime water spray in reflecting sunlight/increasing albedo thereby reducing leaf temperature and transpiration which favourably influenced the RLWC and total chlorophyll and resulted in better growth and yield attributes of cowpea plants grown under water stress situation. Both pod and stover yield as well as dry matter production were highest in plots irrigated at 2 days interval (Farmer's practice) followed by those irrigated at 5 days interval, due to the non exposure of plants to water stress.

Among the treatments, plastic mulching recorded the highest FWUE of 4.74, however it was on par with that of plant residue mulching (4.40) and irrigation at 5 days interval (4.52) due to the advantage of mulching on soil moisture conservation and its reflection on yield (Table 5 and 6). Irrigating the crop at 5 days interval with imposed water stress recorded the lowest FWUE due to the impact of water stress on yield.

Evaluation of economics of cultivation showed that the maximum profit of Rs.94,838/- was noticed in plots irrigated at 2 days interval (Farmer's practice) followed by those irrigated at 5 days interval. Among treatments, plant residue mulching recorded the highest net profit of Rs. 20,371/- followed by seed priming with NaCl (Rs. 14,255/-), whereas all other treatments resulted in a loss due to the extra cost of inputs and labour charge (Table- 7).

Considering the FWUE and economics, in the case of a short term water stress situation, mulching with plant residues and seed priming with 0.5% NaCl were found promising.

Table 6. Effect of treatments on field water use efficiency (FWUE)

Treatments	Quantity of water applied (L)	Field WUE(2cm depth)
Seed priming $CaCl_2$	495	2.92
Seed priming Nacl	495	3.94
Seedpriming $KH2PO_4$	495	2.93
PM	495	4.74
PRM	495	4.40
Kaolin	630	1.87
LWS	630	2.39
Atrazine	630	1.92
Control (Irri. 5 days)	810	4.52
Farmer's practice (Irri. 2 days)	1710	2.99
Control (Irri. 5 days with imposed water stress)	630	1.32
CD(0.05)	-	0.745

Table 7. Economics of cultivation

Treatments	Total cost ($Rs.ha^{-1}$)	Total income ($Rs.ha^{-1}$)	Net Profit /loss^{-1} ($Rs.ha^{-1}$)
Seed priming $CaCl_2$	54,113.00	50,555.40	-3,557.60
Seed priming Nacl	54,059.30	68,314.75	14,255.45
Seed priming KH_2PO_4	54,110.60	50,814.75	-3,295.85
PM	1,37,383.90	82,055.40	-55,328.50
PRM	55,850.60	76,221.95	20,371.35
Kaolin	58,112.20	41,221.95	-16,890.25
LWS	58,092.40	52,629.50	-5,462.90
Atrazine	58,123.00	42,259.00	-15,864.00
Control (Irri. 5 days)	63,450.60	1,28,203.60	64,753.00
Farmer's practice (Irri. 2 days)	84,050.60	1,78,888.85	94,838.25
Control (Irri.5 days with imposed water stress)	57,050.60	29,166.55	-27,884.05

The present study revealed that mulching with plant residues and seed priming with 0.5% NaCl were found beneficial for mitigating water stress in vegetable cowpea grown during summer season in laterite soils of Kerala.

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