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GROWTH, YIELD AND WATER USE EFFICIENCY OF FODDER COWPEA VARIETIES AS INFLUENCED BY WATER STRESS

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SUMMARY

Field experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram during January 2012 to find out the effect of water stress on the growth characters, yield and water use efficiency of fodder cowpea varieties in open and in partial shade. The investigation was conducted as two separate experiments, one in open and another in shaded situation (25-35 per cent shade). The design was laid out in split plot with four replications. The main plot factor included four soil moisture stress levels, M_1: presowing irrigation + life saving irrigation; M_2 :presowing irrigation + irrigation at IW/CPE ratio 0.4; M_3 : presowing irrigation + irrigation at IW/CPE ratio 0.6; M_4 : presowing irrigation + irrigation at IW/CPE ratio 0.8. The sub plot factor included five fodder cowpea varieties, V_1-UPC-618, V_2-UPC-622, V_3-Bundel Lobia-1, V_4-COFC-8 and V_5-CO-5. Based on the results of the study it was concluded that the yield and growth characters such as plant height, number of branches and leaf:stem ratio were significantly higher at IW/CPE ratio of 0.8 both in open and under partial shade. The variety COFC- 8 performed better both in open and shade. Higher WUE was recorded by irrigation at IW/CPE ratio of 0.4 in open and 0.6 in partial shade. Among the varieties, COFC-8 recorded a higher WUE both in open and in partial shade.

Key words : Fodder cowpea, water stress, WUE, growth and yield

Fodder cowpea (*Vigna unguiculata* L. Walp) is a legume inherently more tolerant to drought than other fodder legumes and considered as a crop capable of improving sustainability of livestock production through its contribution in improving seasonal fodder productivity and nutritive value. Fodder cowpea varieties CO-5, COFC- 8, UPC - 618, UPC-622, Bundel Lobia-1 are high yielding and suitable for cultivation in Kerala (Gayathri, 2010). It is the most widely cultivated fodder legume in areas where rainfall is scanty and soils are relatively infertile. Most households that keep livestock raise fodder cowpea as an intercrop with other crops and fodder cowpea forms an integral component of crop livestock farming system (Singh and Tarawali, 2011).

The dairy homesteads of Kerala are mostly experiencing light stress of varying intensities. Poor adaptation of many improved fodder crops/ varieties in shade environment limits fodder production in homesteads and shade affects persistence, yield and quality of understory forages. Evaporative demand is greatly reduced in the shaded environment and soil water availability for the pasture will be maintained at a higher level than in open through the combined effect of less evaporation from soil and lower transpiration rates of the pasture. *V. unguiculata* grows well in shade and is useful as a component crop of silvipastoral systems (Bazil, 2011). Water stress affects photosynthesis directly and indirectly and consequently dry matter production and its allocation to various plant organs. Water use efficiency is the production of moles of carbon gained in photosynthesis in exchange for water used in transpiration. Water use efficiency is an important trait for improving drought tolerance in fodder cowpea, WUE would help save considerable amount of irrigation water. Keeping this in view, the present study was taken up with the following objective of evaluating the performance of drought tolerant varieties of fodder cowpea with respect to growth, yield and water use efficiency under open and shaded situations during the lean dry months.

MATERIALS AND METHODS

A field experiment was conducted in the upland area of the Instructional Farm of College of Agriculture, Vellayani, Trivandrum during the summer season of 2012. The investigation was conducted as two separate experiments, one in open and another in

shaded situation (25-35 per cent shade). The design was laid out in split plot with four replications. The main plot factor included four soil moisture stress levels, M_1: presowing irrigation + life saving irrigation; M_2 :presowing irrigation + irrigation at IW/CPE ratio 0.4; M_3 : presowing irrigation + irrigation at IW/CPE ratio 0.6; M_4 : presowing irrigation + irrigation at IW/CPE ratio 0.8. The sub plot factor included five fodder cowpea varieties, V_1-UPC-618, V_2-UPC-622, V_3-Bundel Lobia-1, V_4-COFC-8 and V_5-CO-5. Presowing irrigation was given to all the plots uniformly upto 10 days after sowing for germination and establishment. Thereafter irrigation was given as per the treatments based on the evaporation data and depth of irrigation. . The quantity of water applied to each plot in one irrigation was 600 litres. FYM @ 10 t ha^{-1} was applied uniformly to all the plots at the time of final preparation of land. Entire dose of phosphorus was given as basal @ 30 kg ha^{-1}. Nitrogen @ 40 kg ha^{-1} and potassium @ 30 kg ha^{-1} were given in two equal splits, one as basal and one after one month of sowing. The fodder cowpea varieties as per treatments were sown at a spacing of 30 x 15cm @ 2 seeds $hole^{-1}$ on 14th January 2012 both in open as well as in shade (25-35 per cent). A single harvest was done in summer season and the growth characters like plant height, number of branches and leaf:stem ratio were recorded. Height of fodder cowpea was measured from the base of the plant to the tip of the longest leaf. Mean height was worked out and presented in cm. The total number of branches of fodder cowpea in the selected observation plants of each plot were also recorded. The sample plants collected for recording dry matter production were separated into leaf and stem, dried, weighed and the leaf:stem ratio was then worked out on dry weight basis. The mean leaf: stem ratio was calculated. The green fodder yield from the net plot area was recorded. Field water use efficiency was calculated by dividing the economical crop yield by the total quantity of water applied in the field (WR) and expressed in kg/ha/mm.

RESULTS AND DISCUSSION

Growth characters

The results of the study revealed that the plant height decreased as the soil moisture stress levels increased. Maximum plant height was recorded at IW/CPE ratio of 0.8 in both open and shade (Table 1).The least plant height was recorded by life saving irrigation (M_1) which was on par with irrigation at IW/CPE ratio of 0.4 (M_2). This might be due to the fact that plants grown under water stress conditions caused a reduction in plant height by reduction of photosynthesis and consequent reduction of internode length. A similar result was also reported by Hajibabaee *et al*. (2012) in forage corn hybrids and by Purbajanti *et al*. (2012) in guinea and napier grasses. Among the varieties, COFC-8 (V_4) recorded higher plant height (101.36 cm), which was on par with that of UPC-618 (V_1). The plant height of UPC- 622 (V_2) (99.30 cm) was on par with that of Bundel lobia-1 (V_3) (98.71 cm). Considerable varietal variations in plant height was also reported by Shekara *et al*. (2012) in fodder cowpea genotypes viz., MFC 08-14, IL-117, UPC-5286, Bundel lobia-1 and UPC-9202. Similar results were also reported by AICRP (2012) in an advanced varietal trial conducted with forage cowpea varieties. None of the interactions were significant.

Under 25-35 % shade, significantly higher plant height (102.89 cm) was recorded by irrigation at IW/CPE ratio of 0.8 (M_4), which was on par with irrigation at IW/CPE ratio of 0.6 (M_3). The least plant height (98.44 cm) was recorded by irrigation at IW/CPE ratio of 0.4 (M_2) which was on par with lifesaving irrigation (M_1) (98.48 cm). Among the varieties, COFC-8 (V_4) recorded higher plant height of 102.31cm. The plant height of 104.98 cm recorded for m_3v_2 (UPC-622 irrigated at IW/CPE ratio of 0.6) was significantly higher which was on par with m_3v_4 (104.43 cm), m_4v_4 (104.35 cm), m_4v_3 (103.70 cm) and m_4v_2 (103.68 cm) (Table 2). Similar result was also reported by Hayatu and Mukhtar (2010) in some cowpea genotypes. The study revealed that soil moisture stress caused reduction in number of branches in both open and shade. The number of branches increased with irrigation at IW/CPE ratio of 0.8. Minimum number of branches was recorded at lifesaving irrigation. Lima *et al.* (2011) reported that reduction in plant branching under water deficit mainly occurs due to low immediate availability of nutrients for the growth conditions because the nutrients are absorbed by the system through the soil solution. The cell expansion is another process that depends on the cell water conditions, also decreasing with the water deficit. The water availability is essential for the vegetative growth, mainly for branch emerging in forage plants. There was significant variation in number of branches between varieties both in open and shade. COFC-8 recorded more number of branches in open and in shade. Considerable variations in number of branches were also reported in some fodder cowpea genotypes by Shekara *et al*. (2012). Similar result was also reported by Hayatu and Mukhtar (2010)

TABLE 1
Effect of soil moisture stress levels and varieties on plant height, number of branches and leaf : stem ratio of fodder cowpea

Treatment	Plant height (cm)		No. of branches		Leaf : stem ratio	
	Open	Shade	Open	Shade	Open	Shade
Soil moisture stress levels (M)						
M_1–Life saving	97.98	98.48	3.70	2.98	0.90	0.94
M_2–IW/CPE = 0.4	98.34	98.44	3.80	3.08	0.94	0.94
M_3–IW/CPE = 0.6	100.14	102.49	4.22	3.23	1.09	0.94
M_4–IW/CPE = 0.8	100.83	102.89	4.57	3.23	1.09	1.01
S. Em±	0.397	0.340	0.075	0.086	0.001	0.002
C. D. (P=0.05)	0.636	0.544	0.121	NS	NS	NS
Varieties (V)						
V_1–UPC 618	99.30	100.54	3.85	3.40	0.90	0.93
V_2 –UPC 622	100.06	101.09	4.33	3.20	1.08	0.95
V_3–Bundel Lobia-1	98.71	100.48	4.03	2.99	1.00	0.94
V_4–COFC -8	101.36	102.31	4.79	3.52	1.18	1.05
V_5–CO-5	97.16	98.42	3.37	2.54	0.86	0.90
S. Em±	0.449	0.475	0.086	0.082	0.092	0.002
C. D. (P=0.05)	0.639	0.675	0.123	0.117	0.131	NS

in seven cowpea genotypes. Results on leaf : stem ratio showed that soil moisture stress levels had no significant influence in open and shade. However, varieties had significant effect in open condition. The fodder cowpea variety COFC-8 recorded significantly higher leaf: stem ratio in open. Considerable variations in leaf: stem ratio was reported in different cowpea genotypes by Shekara *et al.* (2012).

Green Fodder Yield

Results on green fodder yield showed that soil moisture stress levels, varieties and interaction had significant effect both in open and shade. Irrigation at IW/CPE ratio of 0.8 recorded significantly higher green fodder yield in open (Table 3). While irrigating at IW/CPE ratio of 0.8 and 0.6 were on par under shade. Water stress treatment cause decreased water supply and decreased stomatal opening leading to decreased leaf CO_2 absorption followed by decrease in photosynthesis. Finally plant growth is decreased. Moisture stress caused premature aging of leaves, reduction in number of leaves, leaf area, number of branches and thus reduce the yield (Ravarizadesh and Ehsanpour, 2005). In this experiment, increased plant height, number of branches and root dry weight of fodder cowpea at higher irrigation levels contributed to the higher green fodder yield. Green fodder yield was also significantly influenced by the varieties in open and shade. Among the varieties, significantly higher green fodder yield was recorded by COFC-8 followed by UPC-622 in open condition. This resulted due to the higher plant height, number of branches, leaf stem ratio, root shoot ratio and root dry weight recorded by these varieties. In partial shade, COFC-8 recorded maximum green fodder yield followed by UPC-618. This might be due to the higher number of branches produced by these varieties and better uptake of nutrients. Considerable variations in green fodder yield among different cowpea genotypes was reported by Shekara *et al.* (2012). M x V interaction effect was significant in open and shade. COFC-8 irrigated at IW/CPE ratio of 0.8 recorded significantly higher green fodder yield in open and shade and it was on par with irrigation at IW/CPE ratio of 0.6 in partial shade (Table 4). Least green fodder yield was recorded by all the varieties given life saving irrigation. Water stress in plants causes reduced yield and reduction in total biomass through reduction in photosynthesis and plant growth due to leaf senescence. In the case of COFC-8 irrigated at IW/CPE ratio of 0.8, higher plant height in shade, number of branches $plant^{-1}$ and root dry weight in open contributed to high green fodder yield. Similar findings were reported by Hayatu and Mukhtar (2010) in some fodder cowpea genotypes.

The results of the study revealed that both soil moisture stress levels and varieties had significant influence on water use efficiency of the plant in open and shade. Higher WUE was recorded by irrigation at IW/CPE ratio of 0.4 in open and 0.6 in partial shade.

TABLE 2
Interaction effect of soil moisture stress levels and varieties on plant height, number of branches and leaf: stem ratio of fodder cowpea

Treatment	Plant height (cm)		No. of branches		Leaf : stem ratio	
	Open	Shade	Open	Shade	Open	Shade
M x V						
M_1V_1	99.10	99.40	3.32	3.23	0.85	0.92
M_1V_2	97.60	97.63	4.15	2.97	0.96	0.95
M_1V_3	97.23	97.80	3.57	2.82	0.82	0.92
M_1V_4	100.10	100.93	4.5	3.43	1.12	1.02
M_1V_5	95.88	96.63	2.80	2.46	0.77	0.88
M_2V_1	98.60	98.88	3.40	3.36	0.80	0.93
M_2V_2	98.78	98.10	4.18	3.05	1.01	0.93
M_2V_3	98.08	98.23	3.95	2.89	0.99	0.90
M_2V_4	100.33	99.55	4.68	3.48	1.10	1.00
M_2V_5	95.90	97.43	2.97	2.65	0.78	0.92
M_3V_1	100.98	102.08	4.05	3.46	0.99	0.95
M_3V_2	100.03	104.98	4.26	3.45	1.18	0.92
M_3V_3	99.28	102.20	4.11	3.19	1.09	0.91
M_3V_4	101.78	104.43	4.95	3.53	1.25	1.00
M_3V_5	98.63	98.75	3.71	2.53	0.94	0.93
M_4V_1	101.58	101.83	4.60	3.56	0.99	0.93
M_4V_2	100.80	103.68	4.75	3.36	1.18	1.00
M_4V_3	100.25	103.70	4.48	3.10	1.09	1.05
M_4V_4	103.25	104.35	5.03	3.63	1.25	1.20
M_4V_5	98.25	100.88	4.01	2.51	0.94	0.89
S. Em±	0.449	0.475	0.086	0.082	0.092	0.002
C. D. (P=0.05)	NS	1.35	0.783	NS	NS	NS

NS–Not Significant.

TABLE 3
Effect of soil moisture stress levels and varieties on green fodder yield(t ha-1) and water use efficiency (WUE) of fodder cowpea

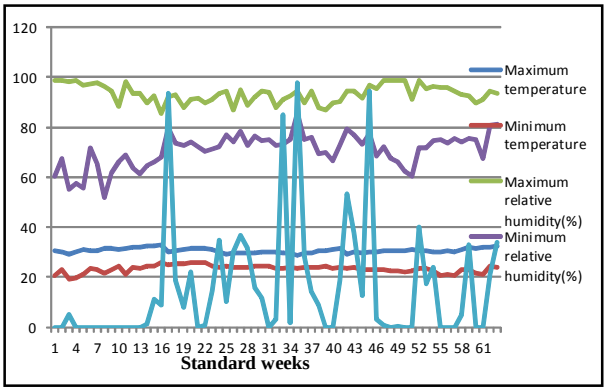
Treatment	Green fodder yield (t/ha)		Water use efficiency (kg/ha/mm)	
	Open	Shade	Open	Shade
Soil moisture stress levels (M)				
M_1–Life saving	15.67	7.44	36.55	17.00
M_2–IW/CPE = 0.4	17.91	8.59	42.95	20.07
M_3–IW/CPE = 0.6	21.46	11.44	41.31	21.65
M_4–IW/CPE = 0.8	24.83	11.80	37.14	17.31
S. Em±	0.236	0.331	1.249	0.671
C. D. (P=0.05)	0.378	0.531	1.999	1.073
Varieties (V)				
V_1–UPC 618	18.93	11.00	37.53	20.95
V_2–UPC 622	21.36	9.76	41.64	18.63
V_3–Bundel Lobia-1	20.34	9.33	40.26	18.21
V_4–COFC -8	24.21	11.50	48.03	22.24
V_5–CO-5	15.01	7.70	29.99	15.01
S. Em.±	0.274	0.290	1.460	0.545
C. D. (P=0.05)	0.390	0.413	2.076	0.775

This might be attributed to the strong sensitivity of cowpea stomata to water stress with reduction in photosynthetic capacity. Supporting results were recorded by Ahmed and Suliman (2010) in fodder cowpea genotypes. They attributed the effect of drought on WUE to stomatal closure, decreased transpiration and decreased leaf turgidity, which have consequences on photosynthesis. Similar results were reported by Volesky and Berger (2012) in warm season annual grasses and Hayatu and Mukhtar (2010) in fodder cowpea genotypes. Significant variations among varieties were also recorded in open and partial shade. Among the varieties, COFC-8 recorded a higher WUE both in open and in partial shade. Isotope discrimination is inversely related to water use efficiency and COFC-8 had higher WUE and lower $_{13}$c. Hamidou *et al*. (2007) showed that stomatal closure is the common strategy used by cowpea genotypes to avoid dehydration. Considerable variations in WUE in fodder cowpea genotypes were reported by Hayatu and Mukhtar (2010).

TABLE 4
Interaction effect of soil moisture stress levels and varieties on green fodder yield (t ha-1) and water use efficiency (WUE) of fodder cowpea

Treatment	Green fodder yield (t/ha)		Water use efficiency (kg/ha/mm)	
	Open	Shade	Open	Shade
M x V				
M_1V_1	14.68	8.07	34.33	18.49
M_1V_2	16.76	7.28	38.66	16.39
M_1V_3	15.84	7.24	37.27	16.70
M_1V_4	19.88	8.56	46.25	19.55
M_1V_5	11.20	6.04	26.26	13.88
M_2V_1	16.88	9.56	40.63	22.42
M_2V_2	18.04	8.40	42.75	19.37
M_2V_3	17.32	8.00	41.78	18.84
M_2V_4	22.24	10.20	53.23	23.78
M_2V_5	15.08	6.80	36.30	15.94
M_3V_1	21.16	12.64	40.72	23.92
M_3V_2	23.63	11.48	45.12	21.55
M_3V_3	21.48	10.84	41.64	20.68
M_3V_4	25.48	13.48	48.99	25.47
M_3V_5	15.56	8.76	30.68	16.65
M_4V_1	23.00	12.92	34.43	18.96
M_4V_2	27.00	11.88	40.01	17.23
M_4V_3	26.72	11.24	40.28	16.63
M_4V_4	29.24	13.76	43.64	20.16
M_4V_5	18.20	9.20	27.34	30.58
S. Em±	0.274	0.290	1.460	0.545
C. D. (P=0.05)	0.784	0.830	NS	NS

NS–Not Significant.



CONCLUSION

Based on the results of the study it was concluded that the yield and growth characters such as plant height, number of branches and leaf:stem ratio were significantly higher at IW/CPE ratio of 0.8 both in open and under partial shade. The results indicated the superiority of the variety COFC- 8 with respect to growth characters, yield and water use efficiency both in open and shade. Higher WUE was recorded by irrigation at IW/CPE ratio of 0.4 in open and 0.6 in partial shade. Among the varieties, COFC-8 recorded a higher WUE both in open and in partial shade.

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