Seed Hydro-Priming and Early Moisture Stress Impact on Biomass Production and Grain Yield of Cowpea

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Abstract

Early moisture stress is often unavoidable when cowpea is grown either for green manure or for grain production in derived savannah of Nigeria. The effects of seed hydro-priming on biomass production and grain yield of cowpea under early moisture stress condition was evaluated in a screen house between August-December 2011, in the University of Agriculture, Abeokuta. The trial was a 4x3x2 factorial in completely randomized design replicated thrice. The factors were priming hours (0, 4, 6, and 8), moisture stress: application of water as from 1, 2 or 3 weeks after planting (WAP), two cowpea varieties (Oloyin and Drum). From the results maximum priming hours were 4 and 6 for Oloyin and Drum respectively. Oloyin primed for 4 hrs had significantly higher dry matter than Drum at 6 WAP under moisture stress condition. However early moisture stress led to significant reduction in seed yield of early maturing Oloyin. Reduction in growth was more with plants from unprimed seeds under severe moisture stress condition. Varieties of the same crop might require varying priming hour; cowpea can be sown after a heavy rain and if rainfall is expected within 21 days after sowing.

Key words: Cowpea; hydro-priming; early moisture stress.

1. Introduction

Cowpea (*Vigna unguiculata* L. Walp) is an annual legume, a grain, vegetable and animal feed crop grown in the semi-arid tropics covering Africa, Asia, Europe, United States and Central and South America. It originated and was domesticated in Southern Africa and was later moved to East and West Africa and Asia (Davis *et al*., 1991; IITA, 2012a). It is one of the most widely used legumes in the tropical world. The grain is used widely for human nutrition, especially in Africa. and as of the most important tropical dual-purpose legumes, used for vegetables (leaves and flowers), grain, as fresh cut and carry forage, and for hay and silage (Whitbread and Lawrence, 2006). The grains contain 25% protein, and several vitamins and minerals. Its adaptability to different types of soil and intercropping systems, as well as its ability to improve soil fertility and prevent erosion makes it an important economic crop in many developing regions (IITA, 2012). The potential of cowpea as a green manure crop is also widely reported (Whitbread and Lawrence, 2006; Fabunmi *et al*., 2012).

In Nigeria, cowpea is often planted from end of July to third week in August depending on the climatic zones: savannah or forest (Dugje *et al.*, 2009; IITA, 2012b). There may however be need to plant it much earlier in the season at the onset of rains, from mid March, if it is meant for green manure production (Fabunmi *et al*., 2012). Growing cowpea within these periods usually exposes it to early moisture stress, either before the rain stabilizes (up to 14 days or more between successive rains) or during the August breaks which may set in either earlier than expected, or be extended beyond the usual, due to climate change. Although cowpea has been reported to be moderately tolerant or resistance to drought (Whitbread and Lawrence, 2006; IITA, 2012), drought stressed has been reported to have had diverse effects on cowpea depending on the growth stage of the plant. According to Akyeampong (2012) cowpea can tolerate drought stress at the vegetative stage and recover when water is available at the reproductive stage without having significant effect on both the dry matter and seed yields, but drought stress at the flowering or pod-filling stage reduced yield.

For the purpose of green manure production however, cowpea growth is terminated at the vegetative stage of growth (6-7 weeks after planting), thus investigating drought stress at this stage is very important as it could guide the farmers on the extent of risk that could be taken for maximum dry matter production. 'On farm' seed priming which entails soaking seeds, overnight, before sowing is a simple technology that farmers can use to improve crop establishment and increase yield (Harris, 2010). Priming seeds improves seedling emergence and stand establishment, resulting in vigorous early growth. This, in turn, leads to faster-maturing crops and higher yields and risk of crop failure is reduced. The rationale of on farm priming is that the first stage in germination of seeds is imbibitions of water. Once sown, seeds spend a great deal of time just absorbing water from the soil. If this time is minimized by soaking seeds in water before sowing (seed priming), seed germination and seedling emergence is more rapid; farmers from Nepal to Botswana have used this technique for generations to "catch up" on time lost in a drought year (Harris, 2012). The aim of this study is therefore to evaluate the effect of seed hydro priming and early moisture stress on biomass production and seed yield of cowpea. The study seeks to address the following objectives:

1. To determine the best priming duration for cowpea
2. To evaluate the effect of seed hydro priming on emergence and dry matter accumulation of cowpea under moisture stress condition.
3. To evaluate the effect of seed hydro priming and early moisture stress condition on seed yield of cowpea.

2. Materials and Methods

The experiment was carried out in the screen house of the Federal University of Agriculture Abeokuta. The trial was a 4x2x3 factorial experiment in a completely randomized design. There were 24 treatment combinations, made up four soaking hour: 0,4,6,8 hour respectively, 2 cowpea varieties (Oloyin and Drum) and three moisture stress conditions, watering from 1, 2 or 3 weeks after planting (WAP).

2.1 Priming Experiment

In the first part of the trial, 600 seeds of Oloyin and 600 seeds of Drum were used. The 600 seeds from each variety were grouped into four, representing the different priming hour treatment, with each group containing 150 seeds. The 150 seeds were then soaked in water for 4, 6 or 8 hours while the seeds used as control were not soaked. At the end of soaking duration, the water was drained out and the seeds weighed in three batches (50 seeds per batch) to represent three replications per treatment. The pre soaked seeds were then air dried. Till the last set of 8 hour soaking was done.

2.2 Screen house Experiment

The screen house experiment commenced, by putting 6.5kg of homogenized top soil into each of 72 pots. Water was added to field capacity to mimic the usual first rain that precedes planting on the field. Six seeds of treated and the control were planted per pot at a depth of 2-3 cm and thinned to four seeds per pot 10 days after planting. Watering was done initially at 1, 2 or 3 WAP according to the treatment, and thereafter, at 3 days interval to prevent further moisture stress apart from the initial imposed treatment.

Data were collected on seed weight at 0, 4, 6 and 8 hours after soaking, days to 100% emergence, canopy height from 1 week after planting and at weekly interval, dry weight at 3 and 6 WAP, days to 50% flowering, number of pods per plant, pod length, number of seed per pod and seed per plant. All data collected were subjected analysis of variance (ANOVA) and the significant treatment means were separated using least significance difference (LSD) at 5% probability level. Genstat discovery edition 3 was used for this purpose.

3. Results

3.1 Effect of hours of seed priming on seed weight gain of cowpea

Priming hour significantly affected weight gain of cowpea seeds in this trial (Figure1). Although there was no significant response to varietal difference, it was observed that variety Oloyin almost attained its peak significant weight gain at 4 hours after soaking, while Drum took additional 2 hours to reach the peak of its seed weight at 6 hours, both varieties had decline in weight gain after 6 hours (Figure 1).

3.2 Effect of cowpea variety and priming hours on days to hundred percent emergence

There was significant varietal response to days to 100% emergence of cowpea seed, with variety Oloyin emerging about one day earlier ($p<0.05$) than Drum (Table1). Priming treatment on the other hand did not have significant effect on seedling emergence.

3.3 Effect cowpea variety, priming hour and early moisture stress on canopy height

Canopy height of cowpea differed significantly between the two varieties ($p<0.05$) at 1 and 6 weeks after planting (WAP) .While Oloyin had higher canopy height at 1 WAP, Drum increased significantly relative to Oloyin at 6WAP (Table 2). Priming hour significantly affected canopy height at 3, 4 and 5 WAP; with 8 hour priming producing significantly taller plant than the control. Although priming showed no significant effect on growth at 1, 2 and 6 WAP, plants resulting from 6 and 8 hour priming showed some superiority. Moisture stress had significant effect on canopy height at 3, 4 and 5 WAP; with plants irrigated from 1 or 2 WAP being at par and having significantly taller canopy than irrigating from 3 WAP between 3-5 weeks of measurement. Although no significant difference was observed at 6 WAP, irrigation from 2 WAP also showed some superiority over those irrigated form 1 and 3 WAP. There were significant interactions between variety and priming hour; variety and irrigation and irrigation and priming hour at 3, 4 and 5 WAP. At 6WAP significant interaction was observed between variety and irrigation. (Table2).

3.4 Effect of priming hours and early moisture stress on dry matter accumulation and days to 50% flowering of cowpea varieties

Response of cowpea varieties Drum and Oloyin to hours of seed hydro priming and early moisture stress is presented in Table 3. There was no significant response between the two varieties in dry matter accumulation at 3 and 6 WAP; however, variety Oloyin accumulated 8.2% dry matter more than Drum at 6 WAP. Although priming did not significantly affect dry matter accumulation both at 3 and 6 WAP, all primed plants produced more dry matter relative to the control. Highest dry matter was recorded from plants that grew from seeds primed for 8 hours. Moisture stress had significant effect on dry matter accumulation both at 3 and 6 WAP. Plants irrigated from 1 or 2 WAP had similar dry matter accumulation ($p>0.05$), which was significantly higher than those from plants irrigated from 3 WAP. Significant interactions were also observed between variety and irrigation and variety and priming hour on dry matter accumulation (Table 3). Variety Oloyin attained 50% flowering about 10 days earlier than variety Drum ($p<0.05$), priming had no significant effect on flowering. Commencement of irrigation at 3 WAP significantly delayed flowering by 3 days relative to either irrigating from 1 or 2 WAP (Table 3).

3.5 Effect of seed hydro priming and early moisture stress on the seed yield and yield component of the cowpea varieties

Effect of seed hydro priming and early moisture stress on the seed yield and yield component of the two cowpea varieties is presented in Table 4. The treatments had no significant influence on pod length and number of seeds per pod. Variety Oloyin produced significantly more number of pods than variety Drum. Early moisture stress also had significant effect on seed yield/pot; with irrigating from 2 WAP showing significant superiority above irrigating from 3 WAP.

3.6 Interactive effects of different factors

Figure 2 shows interactions between cowpea varieties and priming hours on plant height at 1, 3, 4 and 5 weeks after planting respectively. While plant height of Drum increased with priming hours in 3, 4 and 5WAP up to 8 hours of priming, variety Oloyin had taller plants in the control and 4 hours priming relative to other priming hours.

The interactive effect of cowpea varieties and early moisture stress on canopy height is presented in Figure 3. Oloyin consistently had taller plants by commencing irrigation from 2WAP and delaying irrigation till 3WAP significantly led to production of shorter plants, some measure of recovery was however observed as from the 4th and 5th WAP, when irrigation was done. Drum on the other hand had decreased plant height with increased moisture stress, however full recovery was observed at 6WAP.

Figure 4 presents the interactive effect of priming hour and early moisture stress on plant height of cowpea. Commencement of irrigation at 1 or 2 WAP and priming for either 4 or 6 hours showed better growth of cowpea relative to moisture stress for three weeks. The figure also reveals better growth of plants from primed seeds at more severe moisture stress relative to plants from the control. At 5 WAP, plants from seeds primed for 6 hours had similar growth irrespective of the severity of the initial moisture stress.

The interactive effect of variety and early moisture stress (delay in commencement of irrigation) on dry matter of cowpea is presented in Figure 5. The figure revealed that while cultivar Oloyin had the highest dry matter by commencing irrigation from 2WAP, dry matter in Drum decreased steadily with increased moisture stress. The interactive effect of cowpea variety and priming hours showed that while cultivar Oloyin had the highest dry matter by priming for 4 hours, variety Drum had the highest dry matter accumulation by priming for 6hours.
The interactive effect of cowpea variety and early moisture stress on days to 50% flowering of cowpea reveals that while the flowering of early maturing cultivar Oloyin was significantly delayed by about 10 days when irrigation was not applied till 3 weeks after planting, variety
Drum was not affected by early moisture stress (Figure 6).

4. Discussions

Significant interactive effect of cowpea variety and priming hours on both canopy height and dry matter accumulation, in which cultivar Oloyin had the highest dry matter by priming for 4 hours, while Drum had the highest dry matter accumulation by priming for 6hours, could be attributed to thicker seed coat of cultivar Drum relative to Oloyin; thus posing more mechanical barrier to imbibition of water. This finding suggests that caution should be taken in making generalization for the required priming duration of a crop as varietal differences could occur. While reporting on three cultivars of *Phaseolus vulgaris*, Ghassemi-Golezani *et al*. (2010) had concluded that optimal time of hydro-priming for all pinto bean cultivars is 7 hours. On cowpea trial, Eskandari and Kazemi (2011) reported that seedling emergence rate was enhanced by priming seeds in water for 8, 12 or 16 hours; while Maroufi *et al*. (2011) reported that the highest germination percentage, seedling dry weight and seedling vigor were achieved by 6 hours hydro priming of cowpea.

The similarity between the interactive effect of cowpea varieties and early moisture stress on canopy height and dry matter accumulation in this study supports earlier findings that there is considerable variation between cowpea genotypes in tolerance to water stress (Ahmed and Suliman, 2010). Accumulation of more dry matter by Oloyin relative to Drum at 6 WAP, could be attributed to the fact that cultivar Oloyin is early maturing and thus attained peak dry matter production faster than Drum. Response of Drum at 6 WAP supports earlier report that cowpea can tolerate drought stress at the vegetative stage and recover when water is available without having significant effect on the dry matter and seed yields (Akyeampong, 2012); this study however shows that this might be truer for late maturing cowpea cultivar than the early maturing ones. Accumulation of more dry matter by Oloyin when irrigation commenced at 2WAP suggests that at early growth stage, excessive moisture supply could limit growth of some variety, possibly due to more requirement of oxygen for proper root aeration, and this initial growth check might not be overcome in early maturing cultivar like Oloyin. The decrease observed in both plant height and dry matter accumulation, especially of Oloyin, when irrigation commenced at 3 WAP, suggests that the variety can be grown without reduction in growth, if intervals between successive rains are envisaged to be within two weeks. Decrease in growth of Drum with increasing moisture stress for 1-4 WAP, supports earlier findings; as plant height and numbers of leaves of cowpea were reported to have significantly decreased with increasing soil moisture stress (Abayomi and Abidoye, 2009).

The interactive effect of priming hour and time before commencement of irrigation on canopy height of cowpea, suggests that, priming of cowpea seed should not exceed 6 hours. Furthermore; such primed seed should not be exposed to moisture stress beyond two weeks for maximum effect to be achieved. However, better growth of plants from primed seeds at more severe moisture stress relative to plants from the control suggests that seed priming could cushion the effect of early moisture stress. The significant delay observed in the flowering of variety Oloyin as caused by early moisture stress while cultivar Drum was unaffected, can be attributed to the fact that the late maturing cultivar Drum, had more time to compensate for the growth check imposed by the stress before flowering, while for cultivar Oloyin, delayed development in severe early moisture stress was the result. The delay was to enable more biomass to be built up for latter grain filling.

Similarly, Abayomi and Abidoye (2009) had reported that numbers of flowers per plant were significantly decreased with increasing soil moisture stress, while the onset of and date to full flowering were also significantly delayed by higher soil moisture stress levels.

The significant difference observed between Oloyin and Drum in number of pods/plant could be attributed to the genetic makeup of the different varieties. Superiority in seed yield/pot from treatment irrigated from 2WAP relative to the control could be due to the contribution of variety Oloyin as observed in the plant height and dry matter accumulation. This result indicates that although it had been reported that cowpea can be subjected to water stress during the vegetative stage without affecting its final seed yield (Ahmed and Suliman, 2010; Akyeampong 2012), early moisture stress might significantly reduce both the dry matter and grain yield of early maturing varieties.

It can be concluded generally that varieties of the same crop might require varying priming hour and specifically that priming duration of Oloyin and Drum is 4hrs and 6 hrs respectively. Cultivar Oloyin will be a better variety for dry matter production under erratic moisture conditions; this will be of immense benefit to growers of cowpea as green manure before the rains stabilize. Seed priming will enhance the growth of cowpea under early moisture stress conditions especially rain fall is expected at most 2 weeks after planting. Finally, late maturing variety should be chosen for grain production if early moisture stress is envisaged.

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Table 1. Effect of hours of seed priming on days to 100% emergence of two cowpea varieties

Treatment	Days to 100% emergence
Variety	
Drum	5.72
Oloyin	5.03
LSD	0.45
Priming hour	
0	5.67
4	5.33
6	5.44
8	5.08
LSD	NS
V x P	NS

Ns= not significant

Table 2: Effect of varietal difference, priming hour and moisture stress on canopy height of cowpea

Treatment	Canopy height (cm) in weeks after planting					
	1	2	3	4	5	6
Variety						
Drum	9.5	17.7	23.1	27.0	30.4	37.9
Oloyin	11.9	18.4	23.3	27.6	30.9	33.6
LSD	0.78	NS	NS	NS	NS	2.54
Priming hour						
0	10.4	17.4	22.5	25.7	29.9	35.5
4	10.3	18.1	23.0	27.2	29.3	37.0
6	11.0	17.9	23.3	27.1	31.0	36.1
8	11.2	18.7	24.6	29.1	32.4	34.5
LSD	NS	NS	1.5	2.27	0.90	NS
Irrigation						
7	10.1	18.4	25.9	28.4	31.5	34.9
14	11.4	17.3	25.9	29.0	32.1	37.6
21	10.6	18.4	18.4	24.5	28.2	34.8
LSD	0.95	NS	1.29	1.97	0.78	NS
(VXP)	1.56	NS	2.12	3.21	2.55	NS
(VXI)	NS	NS	1.84	2.78	2.21	4.40
(IXP)	NS	NS	2.60	3.93	3.13	NS
(VXPXI)	NS	NS	NS	NS	NS	NS

NS=Not Significant

Table3: Effect of priming duration and moisture stress on dry matter accumulation and days to 50% flowering of cowpea

	Dry weight (g/plant)		
Treatment	3	6	Days to 50% flowering
Variety			
Drum	0.45	1.58	61.7
Oloyin	0.46	1.71	51.3
LSD	NS	NS	1.45
Priming hour			
0	0.51	1.52	56.8
4	0.41	1.71	56.5
6	0.41	1.61	56.9
8	0.49	1.76	55.8
LSD	NS	NS	NS
Irrigation			
7	0.51	1.75	55.1
14	0.53	1.87	55.9
21	0.32	1.32	58.5
LSD	0.12	0.373	1.78
(VXP)	NS	0.609	NS
(VXI)	NS	0.527	2.51
(IXP)	NS	NS	NS
(VXPXI)	NS	NS	NS

NS=Not Significant

Table 4: Effect of cowpea variety, priming hours and early moisture stress on seed yield and yield parameters

Treatment	Pod length (cm)	No of pods/plant	No of seeds/pod	Seed yield/pot(g)
Variety				
Drum	11.8	2.5	7.6	3.0
Oloyin	11.3	3.6	7.4	3.4
LSD	NS	0.57	NS	NS
Priming				
0	11.5	3.5	6.8	3.8
4	11.7	2.8	7.8	2.9
6	10.7	3.2	7.0	2.7
8	12.2	2.6	8.3	3.6
LSD	NS	NS	NS	NS
Irrigation				
7	11.3	3.0	7.4	3.2
14	12.1	3.3	7.9	4.1
21	11.2	2.9	7.2	2.5
LSD	NS	NS	NS	0.93
(VXP)	NS	NS	NS	NS
(VXI)	NS	NS	NS	NS
(IXP)	NS	NS	NS	NS
(VXPXI)	NS	NS	NS	NS

NS=Not Significant

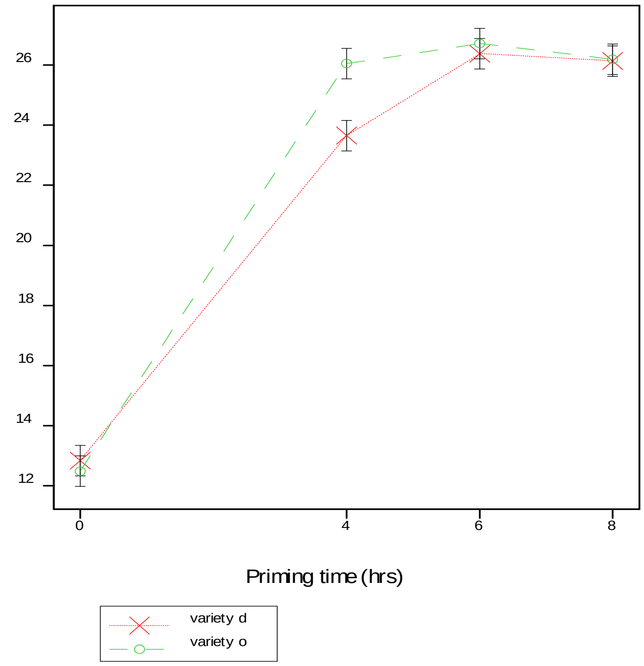
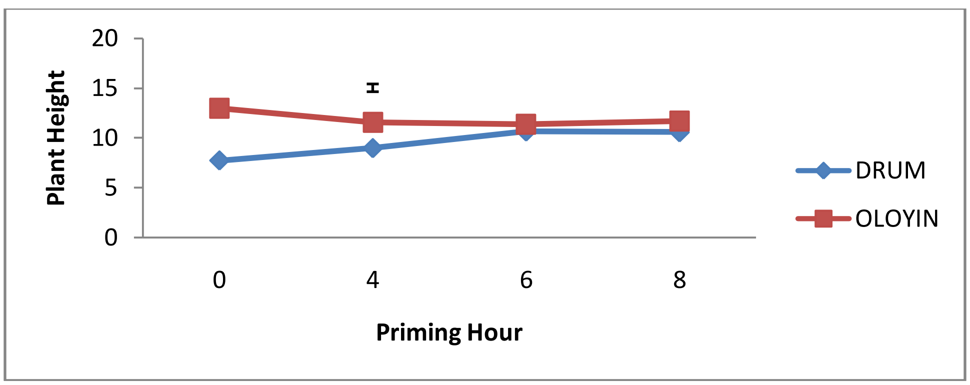
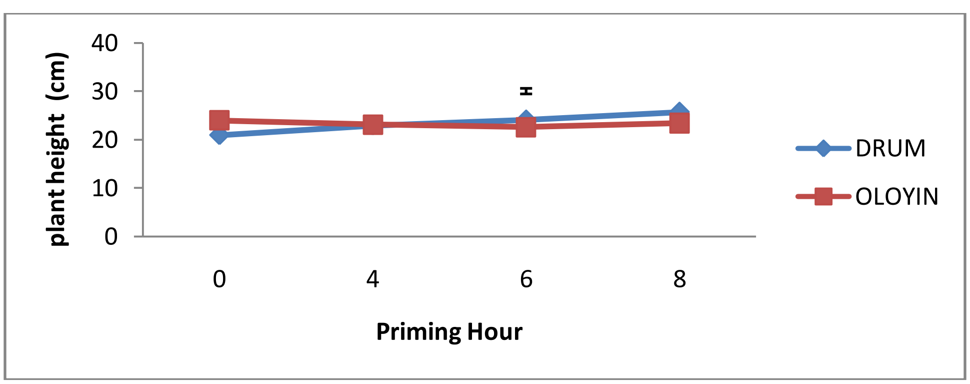


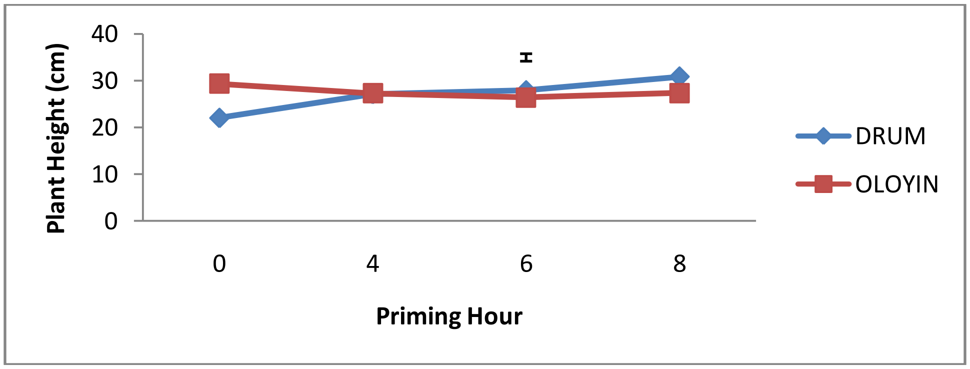
Figure1. Effect of priming hour on seed weight gain of two cowpea varieties –Drum (d) and Oloyin (o)



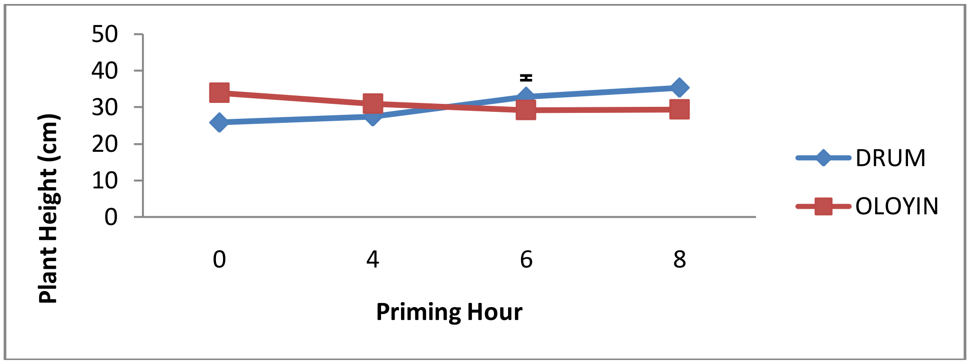
2(a) Interactive effect of Variety and Priming hour on plant height at 1 WAP



2(b) Interactive effect of Cowpea variety and priming hour on plant height at 3 WAP

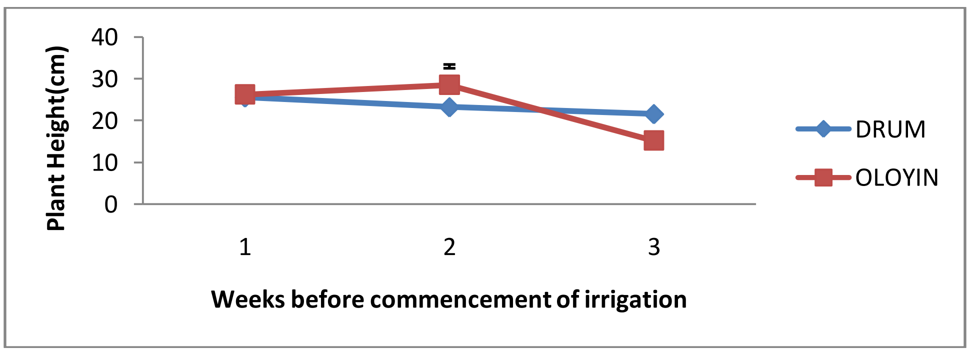


2(c) Interactive effect of Cowpea variety and priming hour on plant height at 4WAP

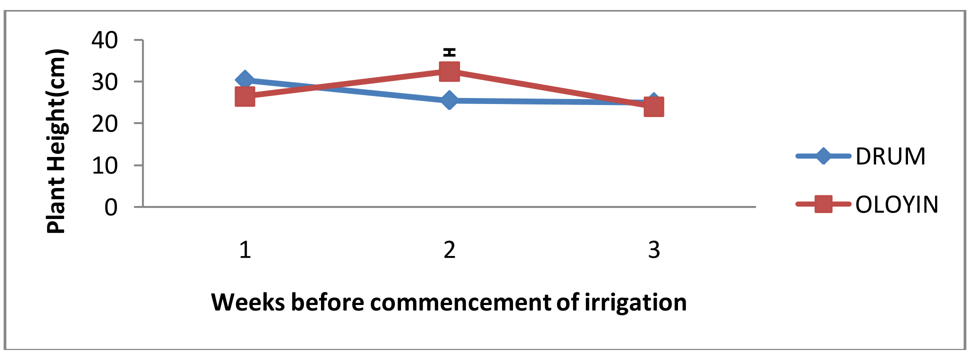


2(d) Interactive effect of Cowpea variety and priming hour on plant height at 5WAP

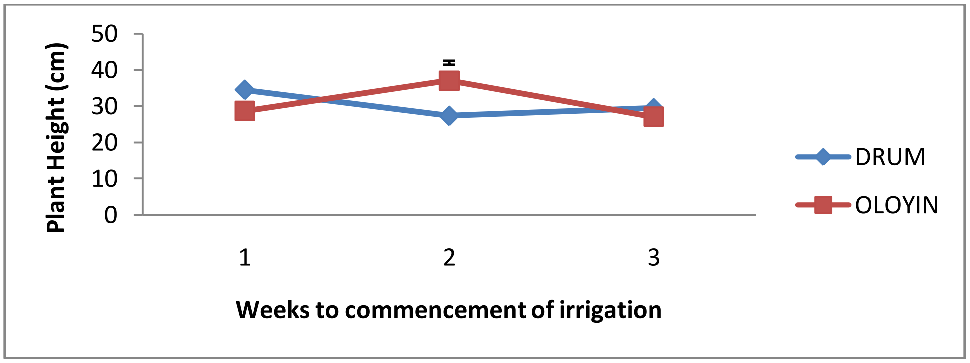
Figure 2: Interactive effect of cowpea variety and priming hour on plant height



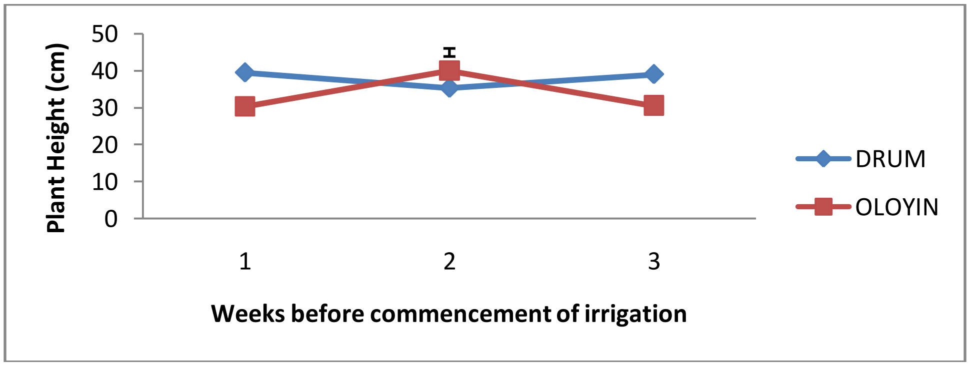
3(a) Interactive effect of Variety and Moisture stress on Plant height at 3WAP



3(b) Interactive effect of Cowpea variety and moisture stress on plant height at 4WAP

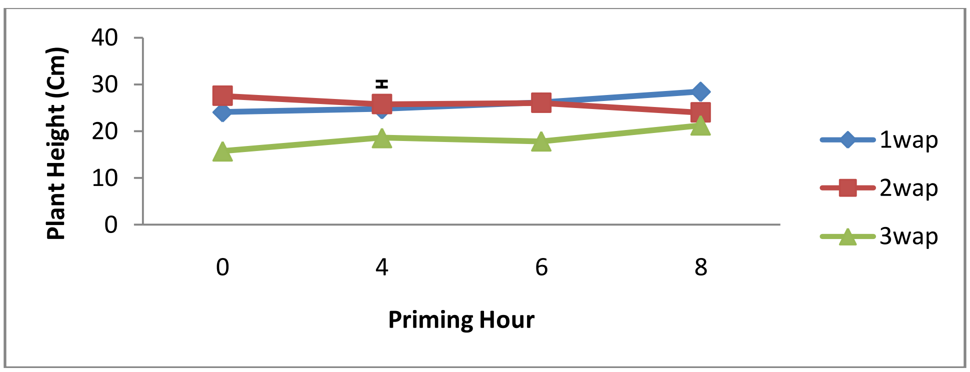


3(c) Interactive effect of Cowpea variety and moisture stress on plant height at 5WAP

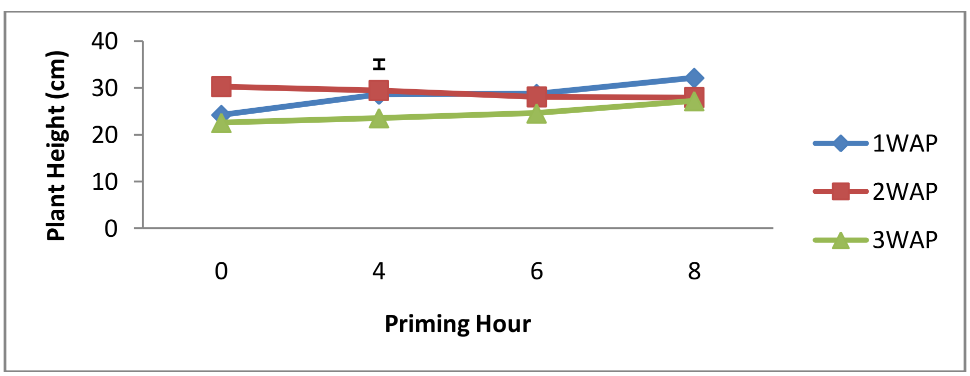


3(d) Interactive effect of Cowpea variety and moisture stress on plant height at 6WAP

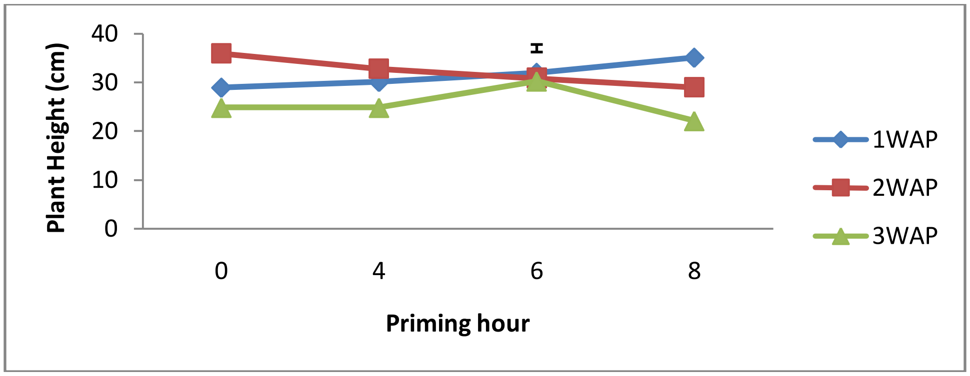
Figure3: Interactive effect of cowpea variety and moisture stress on plant height



4(a) Interactive effect of week(s) before commencement of irrigation and priming hour on plant height at 3 WAP

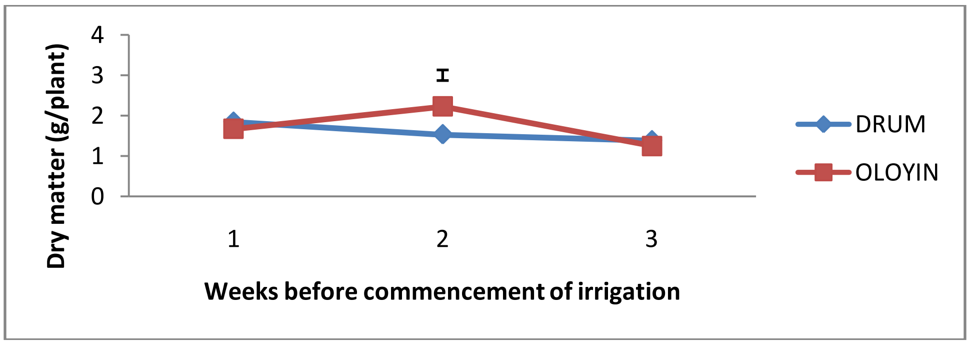


4(b) Interactive effect of week(s) before commencement of irrigation and priming hour on plant height at 4WAP

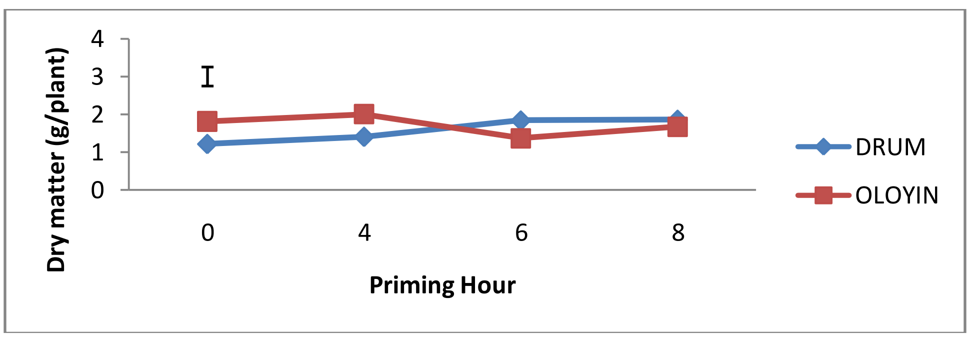


4(c) Interactive effect of week(s) before commencement of irrigation and priming hour on plant height at 5WAP

Figure 4: Interactive effect of Moisture stress and priming hour on plant height



5(a) Interactive effect of Variety and Moisture stress on plant dry matter at 6 weeks after planting



5(b) Interactive effect of Variety and Priming Hour on plant dry matter

Figure5: Interactive effect of Variety and Moisture stress, and Variety and Priming Hour on plant dry matter at 6 weeks after planting

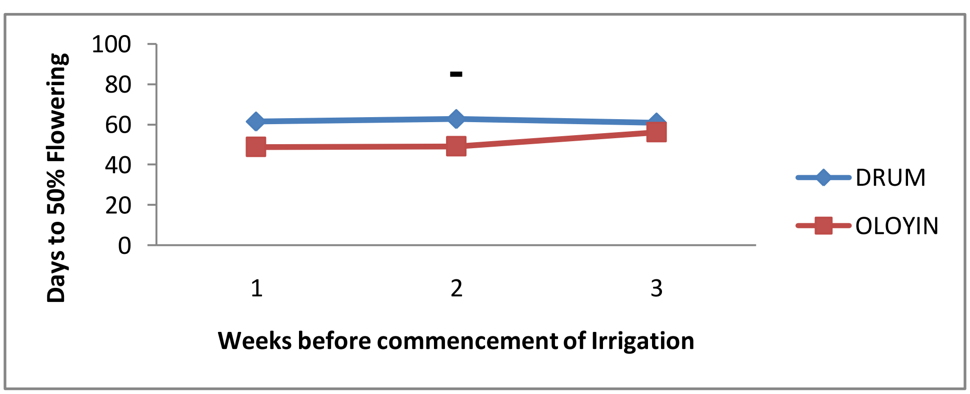


Figure6: Interactive effect of Variety and Moisture stress on Days to 50% flowering