PROJECT REPORT
(UGC PROJECT)

Title

"IMPACT OF CLIMATE CHANGE WITH REFERENCE TO LOW RAINFALL ON SUSTAINABLE PRODUCTIVITY OF PULSE CROPS IN ASSAM"

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Introduction

Stress is defined as any biotic or abiotic factor of environment that affects plant physiology, chemistry; growth and development in such a way that plant perform below the average for a region. Because plants lack the capability of locomotion as a means of responding to changes in their environment, they are exposed to various environmental stresses and must adapt to them in other way. Agricultural productivity worldwide is subjected to increasing environmental constraints, particularly to drought due to their high magnitude of impact and wide distribution. Drought is a meteorological term and can be commonly defined as the absence of rainfall or irrigation for a period of time sufficient to deplete soil moisture and injure plants. Generally, this occurs when a region receives consistently below average precipitation. Of various abiotic stresses known in nature, drought stress poses a major threat to crop production because water is essential at every stage of plant growth from seed germination to plant maturation, so any degree of water imbalance may produce deleterious effects on crop growth. Upon exposure to water deficit, plants exhibit physiological, biochemical and molecular responses at both the cellular and whole plant levels.

There are significant differences in the tolerance of plants to drought stress depending upon its intensity and duration, plant species and the stage of development (Sing et al. 2012). Drought inhibits the rate of photosynthesis of plants by causing changes in chlorophyll content, by affecting chlorophyll components and by damaging the photosynthetic apparatus (Manivannan et al. 2007). The survival of plants in circumstances of water deficiency is dependent on the osmotic adjustment, which promotes accumulation of a range of osmotically active molecules/ions including soluble sugars, sugar alcohols, proline, organic acids, calcium, potassium, chloride ions, etc. (Farooq et al. 2009). These intracellular osmolytes promote water retention and alleviate negative influence of water deficit on plants. Hence, the accumulation of proline in plant tissues can be considered as a clear marker for environmental stress, particularly in plants under drought stress. Low water availability impairing numerous biological roles causing reduction in yield and affects majority of the arable land in the world (Helaly et al. 2005). However, in most plant species this biochemical and physiological changes is not sufficient for survival when severe drought conditions remain constant over time. Thus, the need to generate drought-resistant cultivars is a major challenge for sustainable agriculture (Alcazar et al.2010).

Pulses are legumes that produce seed. They are harvested when dry, and then used for human consumption. They are highly rich in protein content and can substitute for meat in the diet. They provide good quantities of B vitamins. Most tropical pulses are annuals. Green gram (*Vigna radiate* L.) and Black gram (*Vigna Mungo* L.) are two most important pulse crops that are grown in all over India. These are protein rich staple food that contains about 25-26 % protein, which is almost three times that of cereals. In addition, being an important source of human food and animal feed, it also plays an important role in sustaining soil fertility by improving soil physical properties and fixing atmospheric nitrogen. These are short season crop requiring 60 to 90 days from planting to maturity. The present study was therefore performed in sight to gain information on biochemical changes taking place at the cellular level after exposure to various level of water deficit stress and its subsequent relief in relation with growth rate, chlorophyll content, proline accumulation, nitrate reductase activity, concentration of total free amino acid, flavonoid, soluble protein and finally the yield in two major legumes, Green gram (*Vigna radiate* L.) and Black gram (*Vigna Mungo* L.)

Significance of the study

Water is vital for plant growth and development. Water deficit stress, permanent or temporary, limits the growth and distribution of natural vegetation and the performance of cultivated plants more than any other environmental factors do. Although research aimed at improving water stress resistance and water use efficiency have been carried out for many years, the detail mechanism of drought resistance in crop plants needs to be analyzed. Further, the change in water status of plants under stress condition leading to alterations in physiological and biochemical processes can help in developing plant types which sustain their productivity under drought stress condition.

Objectives

1. Impact of drought stress on growth and metabolic aspects of pulse crops commonly grown in Assam.
2. Identification of potential biochemical and morpho-physiological stress indices in plant types.
3. Screening of drought tolerant pulse genotypes for sustainable productivity under changing climatic condition.

Materials and method

Experimental Site

The experiment was conducted during September-November, 2012 at the experimental field of Tezpur University campus which is located at north bank plain zone of Assam (26°14′ N and 92°50′ E) at Tezpur, India. The maximum and minimum average temperature recorded during the experimental period ranged from 22.74 to 22.96° C and the average rainfall recorded was 0.14 mm with a relative humidity of 82.45%. The experimental site is characterized by silt loam textured soil being slightly acidic in nature.

Experimental Design

The site was ploughed with the help of a tractor. Fertilizers were applied at 15:35:10 kg NPK ha^{-1} according to the package of practice of Assam Agricultural University. A temporary rain shed was constructed in the field with PVC (polyvinyl chloride) film (of about 0.15 mm thickness and 85% of transmittance) to avoid rainfall. The experiment was conducted in factorial randomized block design with three replications under stress and non-stress conditions. The genotypes taken were T9, KU 301 (black gram) and Pratap, SG 21-5 (green gram). Seeds of all the genotypes were collected from Regional Agricultural Research Station (RARS), Shillongoni, Nagaon (Assam), India and were sown in the field maintaining the requisite gap of 10 and 30 cm between plants and rows respectively.

Four experiments were conducted

- Experiment- 1 (September- December, 2011): To standardize the field condition and different methods of estimation of biochemical parameters.

- Experiment-2 (September- December, 2012): To study morphological and physiological responses of black gram and green gram genotypes under drought.

- Experiment- 3 (March- June, 2013): To study the changes in biochemical attributes of black gram and green gram genotypes in response to drought.

- Experiment- 4 (September- December, 2013): Repetition of previous experiments with marker morpho-physiological and biochemical traits identified from previous experiments for selection of drought tolerant genotypes of black gram and green gram for sustainable productivity under changing climatic condition.

Treatments for all the experiments were arranged as follows

- T_1– irrigation throughout the growing period (control)
- T_2– withdrawal of irrigation for 15 days at vegetative stage (25 days after sowing)
- T_3– withdrawal of irrigation for 15 days at reproductive stage (35 days after sowing)
- T_4 – withdrawal of irrigation for 15 days at pod filling stage (45 days after sowing)

Soil Analysis

Soil moisture content in the drought and control field was monitored by taking soil samples from a depth of 15 cm at respective sites for each block. Before sowing, soil samples were collected from the experimental field, processed and analyzed for various physico-chemical parameters (e.g. bulk density, soil pH, water holding capacity, soil available nitrogen and organic matter content). Gravimetric method (Black, 1965) was employed to estimate the moisture content of soil throughout the crop growing period. Soil tensiometers were used to record soil water potential. Organic matter content of soil was determined by Walkley and Black method (modified) (1934).

Morphological measurement

For morphological measurements, three central plants of each block was selected and labeled. Measurements over time were taken always from the same three plants. Plant height (cm) was measured using a meter ruler by averting the distance from soil level to the top of each plant.

The leaf area of the cultivars at 7 days interval was recorded using laser leaf area meter (CI-203, USA). Leaf area index (leaf area per unit ground surface area) was calculated using this value.

Physiological measurement

Relative leaf water content

Fresh weight of leaf samples were recorded and then were submerged in distilled water. After 12 hours, turgid weight was recorded and finally was dried at 70°C for 48 h and was weighed again. Relative leaf water content (RLWC) is calculated as {(FW-DW)/ (TW-DW)} ×100 (Lin and Ehleringer 1982).

Leaf water potential

Leaf water potential was recorded with the help of pressure chamber (model 615, PMS Instrument, USA).

Photosynthesis

Photosynthetic efficiency of different cultivars will be measured using portable photosynthesis system (LI-6400, USA) at regular interval.

Biochemical measurement

Estimation of leaf proline content

Free proline was extracted from 500 mg of fully expanded fresh leaf samples homogenized with 3% sulfosalicylic acid and estimated by using acid ninhydrin reagent according to the protocol described by Bates et al. (1973). The absorbance of fraction with toluene aspired from liquid phase was determined by using UV-visible spectrophotometer (UV-1700 series, Pharma Spec, Japan) at 520 nm. Contents of proline were expressed as μ mol g^{-1} fresh weight.

Estimation of total flavonoid content

Flavonoid and anthocyanin were extracted from fresh leaf discs by keeping them in acidified methanol (methanol: water: HCl, 78:20:2V/V) for 24 hours at 4 ^{o} C (Jordan et al. 1994). The filtered extract was then used for measuring the absorbance at 320 nm and 530 nm for flavonoid and anthocyanin respectively which is indicative of relative concentration of light absorbing pigments. Flavonoid and anthocyanin contents were expressed as absorbance g^{-1} fresh weight of tissue at 320 nm and 530 nm respectively.

Estimation of leaf chlorophyll content

Chlorophyll-a, chlorophyll-b and total chlorophyll were determined by the method of Anderson and Broadman (1964). Chlorophyll stability index was calculated using the following formula

CSI (%) = (Total Chlorophyll under stress/Total Chlorophyll under control) × 100

Extraction and estimation of nitrate reductase activity

Nitrate reductase activity was assayed by the procedure of Jaworski (1971) based on the incubation of fresh tissue (0.2 g) in 5 ml medium containing 0.1M phosphate buffer (pH 7.5), 0.2 M potassium nitrate, 5% propanol and 2 drops of chloramphenicol. After keeping in dark at 25°C for 24 hours, 0.4 ml aliquot was treated with 0.3 ml each of 1%sulphanilamide in 3 M HCL and 0.02% N-(1-napthyl)-ethylediamine dihydrochloride (NEDD). The absorbance was measured at 540 nm. NR activity was calculated with a standard curve prepared using KNO_3 and expressed as μ mol NO_2^- h^{-1} g^{-1} fresh weight.

Estimation of total free amino Acid

For estimation of total free amino acid content, 0.5 g of leaf sample was homogenized in 10 ml of 80% ethanol and then centrifuged for 10 minutes at 800 g. To 1 ml of this extract, 1 ml of 0.1 N HCl was added to neutralize the sample. One ml of ninhydrine reagent was added to this mixture and heated for 20 minutes in a boiling water bath. Later, 5 ml of the diluents solution was added and heated again in water bath for 10 minutes. The test tubes were cooled and read the absorbance at 570 nm in a UV-spectrophotometer (Moore and Stein, 1944).

Estimation of Total soluble protein

Fresh 500 mg leaves were homogenized in 0.1 ml of phosphate buffer (pH 7.5). The extract was centrifuged at10000 g for 20 min at 4° C and supernatant obtained was used for protein determination and enzyme assay. Total soluble protein will be estimated by the method of Lowry et al. (1951) using bovine serum albumin (BSA) as a standard.

Yield and yield attributing parameters

To study the overall effect of drought on yield components, harvesting was done when 75% of the pods mature indicating full darkish pod and brittle on slight pressure. Various yield and yield attributing parameters like number of pod per plant, seeds per pod and finally the weight of seeds per plant were recorded. From these data we obtained the following yield indexes

Mean productivity (MP): (Yield control + Yield drought)/2
Rate productivity (RP): Yield drought/ Yield control
Drought tolerance index (DTI): (Yield drought × Yield control)/ Mean yield control
Harvest index: (Economic yield/ biological yield) × 100

Soil water potential (Ψ_S) of -0.15 to - 0.25 bar was maintained in the control plots with irrigation throughout the growing season while in the treated plots -0.65 to - 0.75 bar of the same was recorded after withholding of irrigation for 15 days.

Experimental layout

C_1T_1	C_2T_1	C_3T_1	C_4T_1
C_1T_2	C_2T_2	C_3T_2	C_4T_2
C_1T_3	C_2T_3	C_3T_3	C_4T_3
C_1T_4	C_2T_4	C_3T_4	C_4T_4
C_2T_1	C_3T_1	C_4T_1	C_1T_1
C_2T_2	C_3T_2	C_4T_2	C_1T_2
C_2T_3	C_3T_3	C_4T_3	C_1T_3
C_2T_4	C_3T_4	C_4T_4	C_1T_4
C_3T_1	C_4T_1	C_1T_1	C_2T_1
C_3T_2	C_4T_2	C_1T_2	C_2T_2
C_3T_3	C_4T_3	C_1T_3	C_2T_3
C_3T_4	C_4T_4	C_1T_4	C_2T_4

C_1- T9

C_2- KU 301

C_3- Pratap

C_4- SG 21 5

Results

Soil parameters:

At beginning of the experiment, soil samples were collected from the field and analyzed to determine its various physico-chemical properties such as bulk density, pH, water holding capacity, organic matter content etc., the results of which are presented in the table below:

Table 1: Physico-chemical parameters of the soil

Soil parameters	**Results**
Bulk density (Db)	1.34 gram/cc
pH	6.54
Water holding capacity	52.8%
Organic matter content	0.28%

Soil moisture content was determined for all treatments during the stressed period. Results are as follows:

Table 2: Moisture content (%) of the soil for each treatment during experimental period (mean± standard error)

Growth stages	Control (%)	Stress (%)
Vegetative	85±0.16	51±0.12
Early reproductive	86±0.10	49±0.15
Pod filling	85±0.18	50±0.16

Morphological measurement

Effect of drought stress on plant height

Application of drought stress for fifteen consecutive days had significant impact on plant height of both black gram and green gram. Mean values of the data indicated that this impact was more prominent in KU 301 and SG 21 5 for all the treatments. Water stress during vegetative stage was most detrimental in terms of height. No significant impact of drought on plant height was observed when stress was applied during pod filling stage.

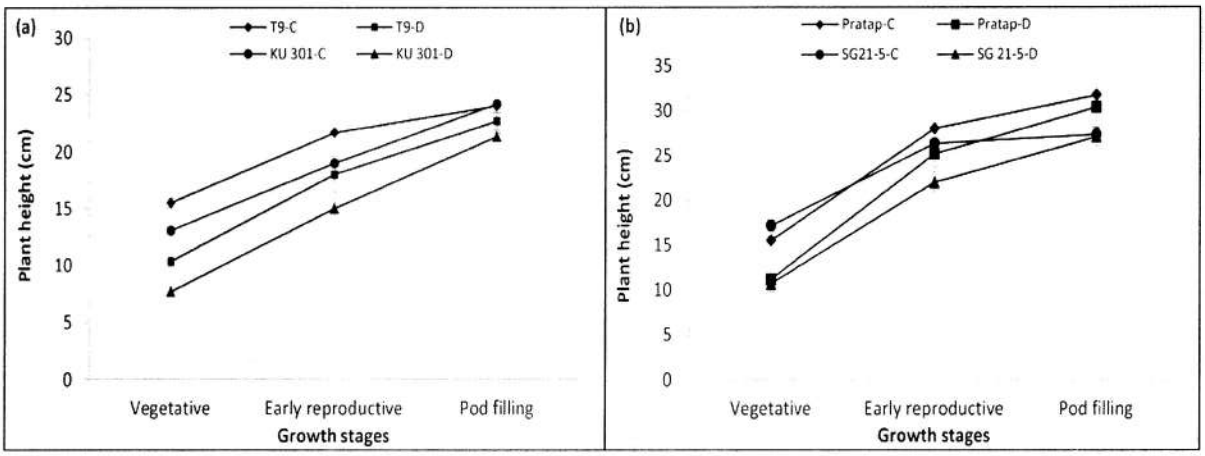


Figure 1. Effect of drought on plant height of (a) black gram and (b) green gram (Error bars indicate ± SE; C-control, D- drought)

Effect of drought stress on leaf number

Significant reduction in leaf number of black gram and green gram plants were observed when subjected to stress for 15 days. Genotypes T9 and Pratap maintained higher leaf number in both the conditions than KU 301 and SG 21-5. Plants stressed at vegetative stage (T_2) recorded highest reduction in leaf number (T9-30.18%, KU 301-31.14%, Pratap-33.89%, SG 21-5-39.62%). We observed that leaf abscission was highest in the plants experiencing drought during pod filling stage (T_4) in comparison to other treatments.

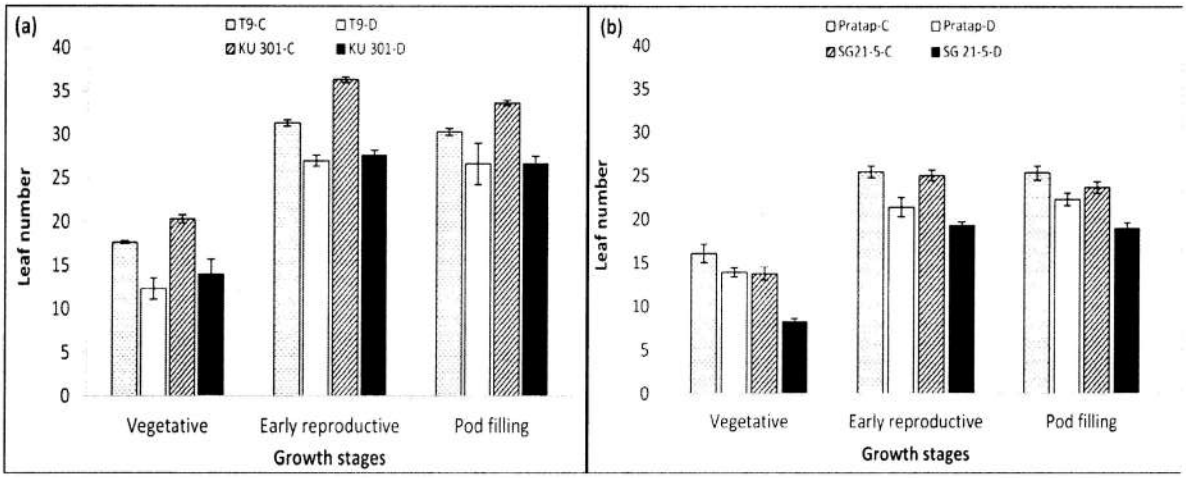


Figure 2. Effect of drought on leaf number of (a) black gram and (b) green gram (Error bars indicate ± SE; C-control, D- drought)

Effect of drought stress on leaf area

Total leaf areas of stressed plants were significantly lower than the control plants. Greater reduction in leaf area was observed in KU 301 and SG 21-5 in all the treatments. Plants stressed during vegetative stage (T_2) showed highest reduction of leaf area in all the genotypes.

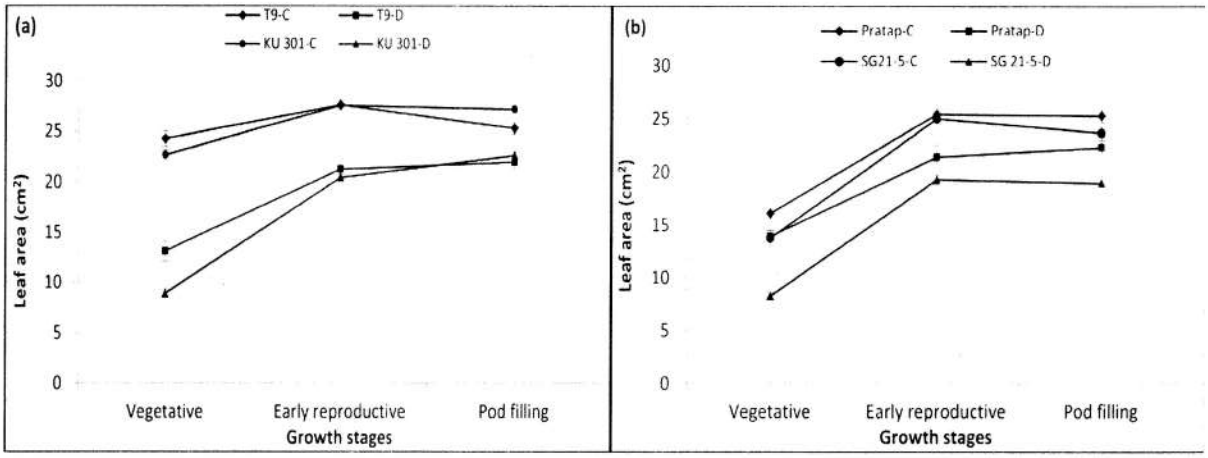


Figure 3. Effect of drought on leaf area of (a) black gram and (b) green gram (Error bars indicate ± SE; C-control, D- drought)

Physiological measurement

Effect of drought stress on Relative leaf water content (RLWC)

Significant decrease in relative leaf water content (RWC) was observed in all the treatments. Genotypes T9 and Pratap maintained better water balance in leaves as compared to KU 301 and SG 21-5 in all the stages of growth.

Table 3. Relative leaf water content (RLWC) of black gram and green gram genotypes under control and stress condition (mean± standard error, C- control, D- drought)

Genotypes		Relative leaf water content (%)		
		Vegetative	Early reproductive	Pod filling
T9	C	86.33±0.09	85.96±0.27	82.84±0.33
	D	77.47±0.77	70.40±1.20	65.04±0.58
KU 301	C	89.27±0.27	88.54±0.08	84.05±0.11
	D	72.21±1.09	62.30±0.85	61.02±0.12
Pratap	C	88.39±0.17	85.53±0.25	84.16±0.21
	D	75.97±1.19	65.55±0.32	64.73±0.52
SG 21-5	C	86.89±0.31	84.96±0.12	83.53±0.29
	D	68.06±0.67	60.04±0.97	60.66±1.49

Effect of drought stress on leaf water potential

A decrease in mid-day leaf water potential (Ψ_L) was observed in the plants treated with deficit irrigation for fifteen consecutive days compared to the control plants. However this decreasing trend was most prominent in the genotype TMB 37 in all the stages of growth. No significant change in Ψ_L was observed in control plants throughout the experimental period as they were watered regularly.

Table 4. Leaf water potential (Ψ_L) of black gram and green gram genotypes under contro and stress condition (mean± standard error)

Genotypes	Stages	Leaf water potential (-M Pa)	
		Control	Drought
T9	Vegetative	0.81±0.04	1.51±0.09
	Early reproductive	1.21±0.03	2.32±0.17
	Pod filling	1.32±0.09	1.94±0.05
KU 301	Vegetative	1.11±0.12	1.73±0.12
	Early reproductive	1.22±0.13	2.40±0.07
	Pod filling	0.92±0.07	2.13±0.15
Pratap	Vegetative	0.61±0.11	1.51±0.09
	Early reproductive	1.22±0.05	2.01±0.07
	Pod filling	1.30±0.09	1.93±0.05
SG 21-5	Vegetative	1.41±0.12	1.74±0.15
	Early reproductive	1.21±0.03	2.42±0.07
	Pod filling	1.43±0.07	2.11±0.05

Effect of drought stress on photosynthesis

Drought stress significantly affected the rate of photosynthesis of all the studied genotypes. However, this reduction was more prominent in KU 301 and SG 21 5 as compared to other two genotypes. Plants subjected to drought during vegetative stage showed greater reduction in photosynthesis rate (Pn) than other two treatments. Control plants maintained highest Pn throughout the growing period.

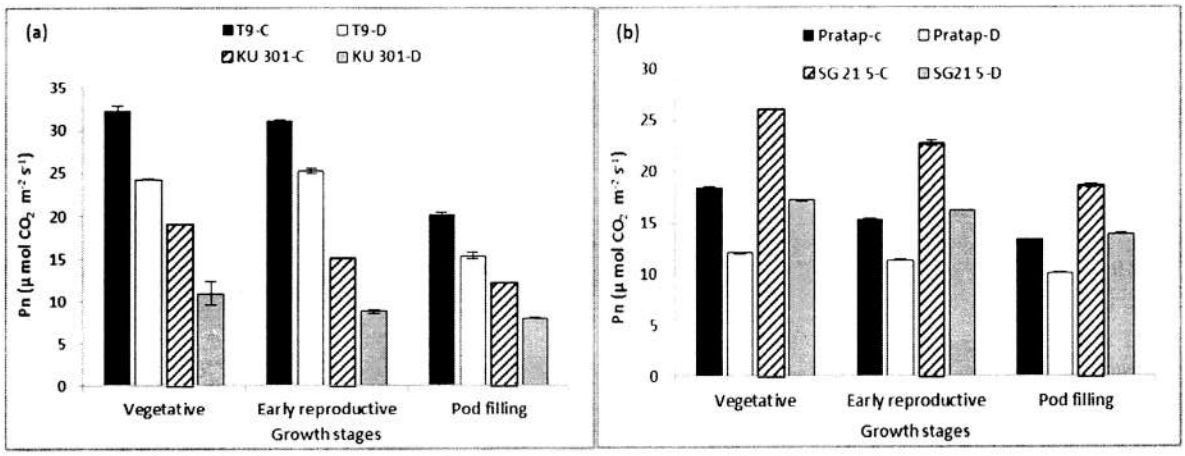


Figure 4. Effect of drought on photosynthesis rate (Pn) of (a) black gram and (b) green gram (Error bars indicate ± SE; C-control, D- drought)

Biochemical measurement

Effect of drought stress on leaf proline content

Application of stress significantly increased the level of leaf proline content of black gram and green gram. The increased accumulation of proline in leaves due to drought stress was more pronounced at early reproductive stage than vegetative and pod filling stages. In all the treatments, T9 and Pratap maintained higher level of proline than KU 301 and SG 21-5.

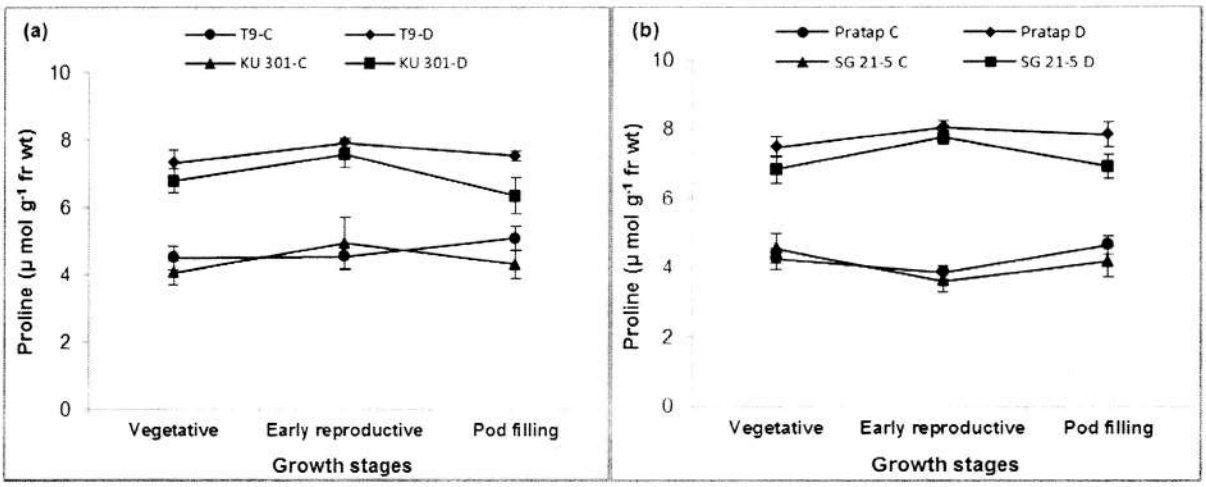


Figure 5. Effect of drought on leaf proline content of (a) black gram and (b) green gram ((Error bars indicate ± SE; C-control, D- drought)

Effect of drought stress on total flavonoid content

In the present experiment, an increasing trend of total flavonoid content was observed under stress condition as compared to the plants grown under well watered environment. Highest increment in the level of total flavonoids was observed in the plants treated with deficit irrigation during early reproductive stage. Genotypes T9 and Pratap maintained higher levels of total flavonoid than other two genotypes in all the treatments.

Table 5. Total flavonoid content of black gram and green gram genotypes under control and stress condition (mean± standard error)

Genotypes	Stages	Total flavonoid (absorbance g^{-1} fr wt)	
		Control	Drought
T9	Vegetative	15.66±0.65	16.02±0.39
	Early reproductive	16.62±0.30	17.23±0.25
	Pod filling	17.06±0.06	17.36±0.05
KU 301	Vegetative	14.41±1.84	15.03±1.26
	Early reproductive	16.36±0.46	16.77±0.01
	Pod filling	17.13±0.18	17.41±0.32
Pratap	Vegetative	14.82±0.98	15.03±1.64
	Early reproductive	16.63±0.67	17.19±1.19
	Pod filling	16.80±0.30	16.98±0.67
SG 21-5	Vegetative	15.70±1.70	15.92±1.19
	Early reproductive	16.90±0.61	17.31±0.15
	Pod filling	16.71±1.38	16.87±0.46

Effect of drought stress on leaf chlorophyll content

In the present study, chlorophyll-a, b (data not presented) and total chlorophyll content showed a decreasing trend under stress condition as compared to the plants grown under well watered environment. At all the stages of growth, T9 and Pratap maintained higher level of total chlorophyll than KU 301 and SG 21-5 in both control and stressed plants.

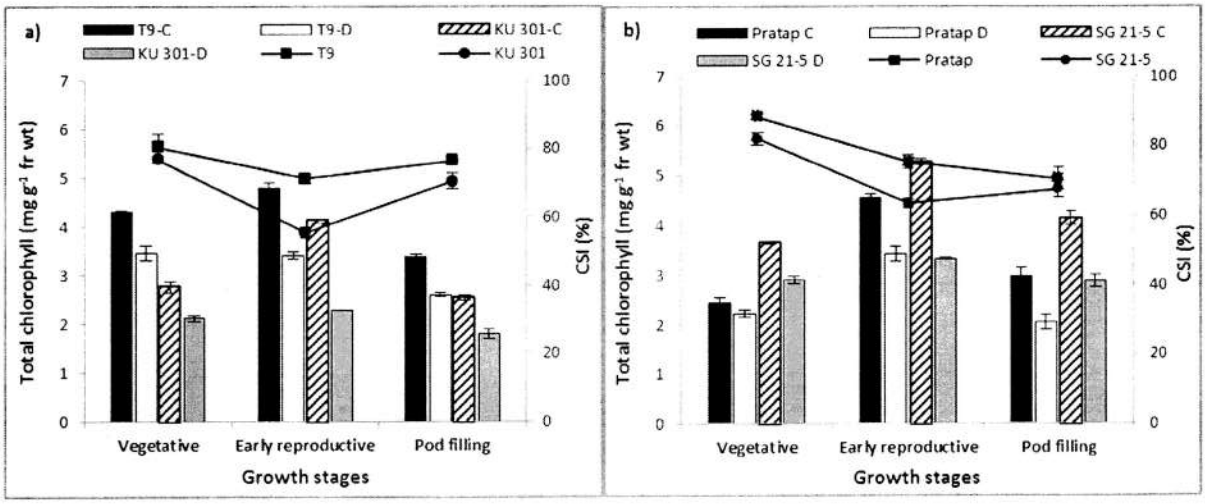


Figure 6. Effect of drought on total chlorophyll content and chlorophyll stability index (CSI) of (a) black gram and (b) green gram (mean values ±SE, C- control, D- drought)

Chlorophyll stability index of both black gram and green gram was found to decrease under drought. The drop down of CSI was higher in KU 301, SG 21-5 than T9, Pratap throughout the crop growing season. In both the crops, the highest value of CSI was obtained at vegetative stage while the lowest was recorded at early reproductive stage.

Effect of drought stress on nitrate reductase activity

Nitrate reductase activity (NRA) in the leaves of gram plants subjected to moisture stress decreased significantly during stress period. T9 and Pratap recorded higher NRA in all the treatments expressing their more tolerance capacity towards osmotic stress. Maximum reduction in the activity of NR was recorded at early reproductive stage followed by vegetative and pod filling stages.

Table 6. Nitrate reductase activity (NRA) of black gram and green gram genotypes under control and stress condition (mean± standard error)

Genotypes	Stages	NRA (μ mol NO_2^- h^{-1} g^{-1} fr wt)	
		Control	Drought
T9	Vegetative	2.41±0.01	1.43±0.03
	Early reproductive	3.88±0.04	2.32±0.04
	Pod filling	3.01±0.05	2.04±0.06
KU 301	Vegetative	3.16±0.03	1.63±0.04
	Early reproductive	3.59±0.04	2.60±0.02
	Pod filling	3.30±0.04	2.44±0.02
Pratap	Vegetative	2.56±0.12	2.20±0.32
	Early reproductive	2.79±0.11	1.84±0.20
	Pod filling	2.33±0.28	1.56±0.12
SG 21-5	Vegetative	2.36±0.24	1.92±0.12
	Early reproductive	2.72±0.16	1.40±0.12
	Pod filling	2.24±0.12	1.24±0.04

Effect of drought stress on total free amino acid and soluble protein content

Total free amino acid content was found to be increased under stress condition. Similar trend of increment was followed by all the genotypes irrespective of their growth stages (Figure 7). Control plants recorded the lowest concentration of amino acids while plants stressed during flowering stage recorded the highest concentration of the same. But, total soluble protein decreased significantly after 15 days of water deficit (Figure 8). In vegetative stress, the drop down of total soluble protein was 8.79-46.15%, in flowering stress 21.67-57.32% and in pod filling stress 5.64-34.12%.

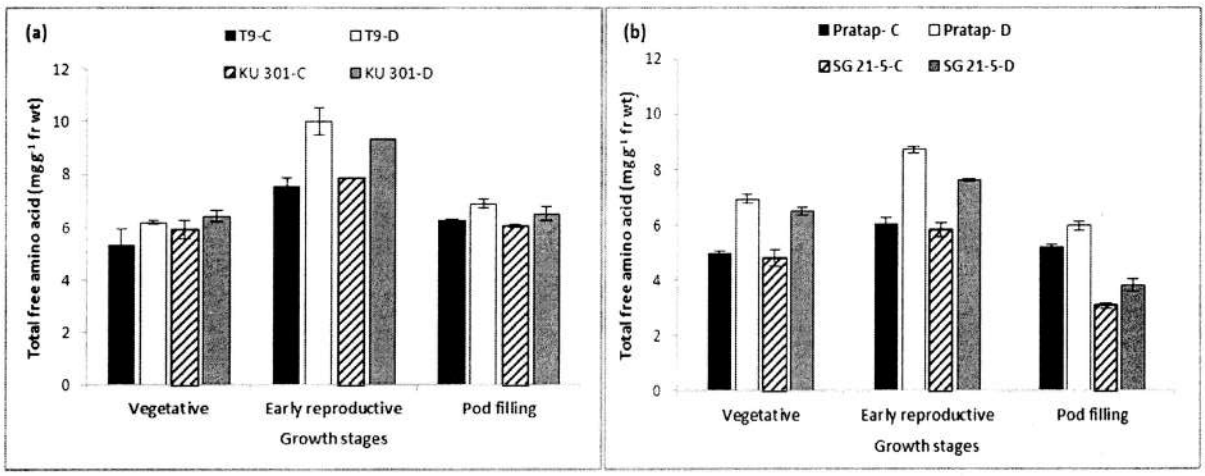


Figure 7. Effect of drought on total free amino acid content of (a) black gram and (b) green gram (mean values ±SE, C- control, D- drought)

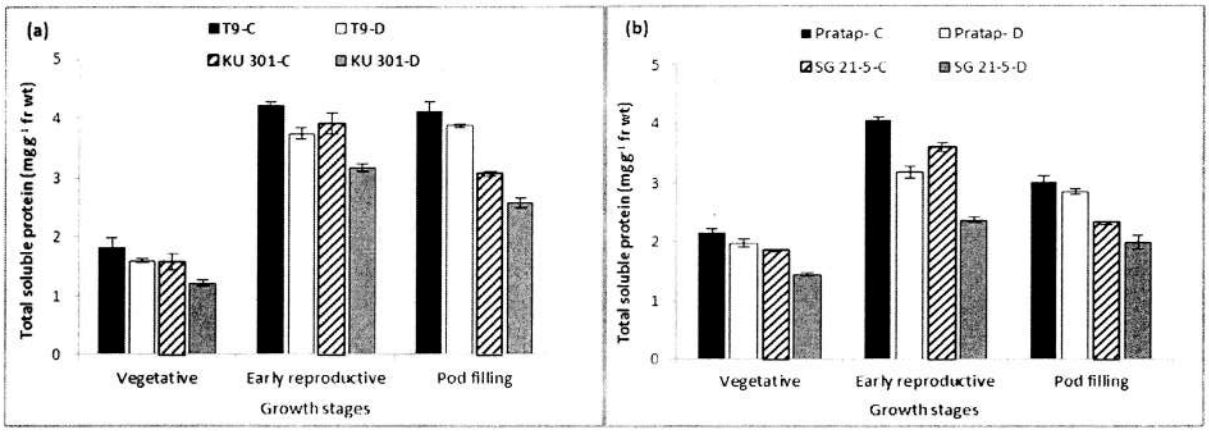


Figure 8. Effect of drought on total soluble protein content of (a) black gram and (b) green gram (mean values ±SE, C- control, D- drought)

Effect of drought stress on yield and yield attributing parameters

Yield loss due to drought was more pronounced in KU 301 and SG 21-5 than T9 and Pratap for all the treatments (Table 02). The percentage reduction in yield was highest in T_3 plants (T9- 31.28%, KU 301- 48.52%, Pratap-37.12%, SG 21-5- 56.98%) and it was in the order of $T_3>T_4>T_2$. Drought had a pronounced impact on various yield indexes. Higher values of mean productivity (MP), rate productivity (RP), and drought tolerance index (DTI) were obtained for

T9 and Pratap (Table 02 and 03). These two genotypes also recorded greater value of harvest index (HI) irrespective of treatments.

Table 7. Seed yield, mean productivity (MP) and rate productivity (RP) of black gram and green gram (mean± standard error)

Genotypes	Seed yield (q/ ha)				MP	RP
	T_1	T_2	T_3	T_4		
T9	11.14±0.02	9.95±0.03	7.65±0.12	8.08±0.04	9.21	0.77
KU 301	10.75±0.04	8.34±0.03	5.53±0.03	6.05±0.07	7.67	0.62
Pratap	12.04±0.09	10.07±0.04	7.57±0.05	8.24±0.06	9.48	0.72
SG 21-5	12.26±0.02	9.15±0.06	5.28±0.02	7.65±0.02	8.58	0.60

Table 8. Harvest index (HI) and drought tolerance index (DTI) of black gram and green gram

Genotypes	Harvest index (%)				DTI
	T_1	T_2	T_3	T_4	
T9	51.37	48.56	46.52	43.38	8.71
KU 301	52.86	42.06	36.59	37.30	6.52
Pratap	53.31	48.85	44.22	43.86	8.55
SG 21-5	51.05	41.80	31.38	39.87	7.42

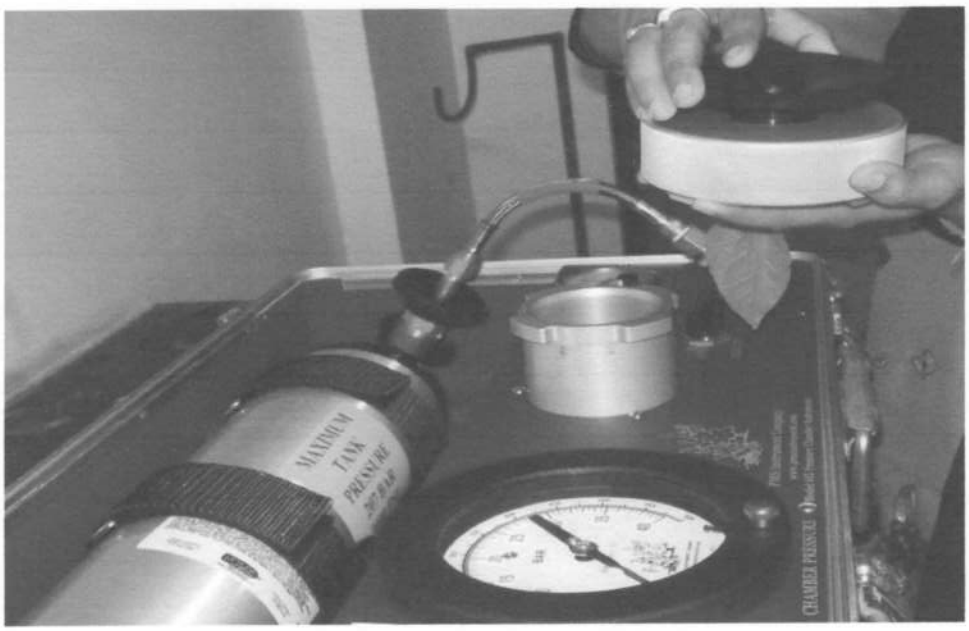
Conclusion and recommendation

A remarkable impact of drought had been observed on morphological, physiological, biochemical and yield characteristics of these two pulses. The studied morpho-physiological traits may be interesting for selection of drought tolerant genotypes for improved productivity in drought prone environments, as these are relatively simple to evaluate. The impact of drought was more pronounced in genotypes KU 301 and SG 21-5 indicating better tolerance capacity of T9 and Pratap to cope up with this adverse condition. Leaf water potential, relative leaf water content, Leaf proline, chlorophyll, total free amino acid contents and nitrate reductase activity have been identified as marker trait for selecting drought resistant genotypes of black gram and green gram. These two crops are sensitive to water shortage at all growth stages, but particularly early reproductive development was found to be most sensitive period to drought stress. It is therefore very much essential for farmers ensure that their crops must not suffer from water scarcity during this critical growth period. This information can be used for the selection of drought tolerant genotypes in the course of breeding and farmers can go for these two genotypes where irrigation facility is limited.

Preparation of seed beds

Seventeenth day after sowing

Ongoing experiment



Recording leaf water potential

Seminars and conferences attended

- "4th International Congress of Environmental Research", December 15-17, 2011, Surat, India.

  Title- **Effect of induced drought on different growth and biochemical attributes of black gram (*vigna mungo l.*) and green gram (*vigna radiate* L.).**

- "First International conference of Bio resource and Stress Management", February 6-9, 2013, Kolkata, India.

  Title- **Biochemical changes in two *Vigna* spp. during drought and subsequent recovery**.

- National Seminar on "Climate Change and Climate Resilient Agriculture", March 18 & 19, 2013, Biswanath Chariali, Sonitpur, Assam.

  Title- **Morphological Responses of Pulse (*Vigna* spp.) Crops to Soil Water Deficit**.

- International Conference on "Harnessing Natural Resources for Sustainable Development- Global Trend", January 29-31, 2014, Cotton College, Guwahati, Assam, India.

  Title- **Assessment of Biochemical Changes in Black gram (*vigna mungo* L.) Genotypes after Imposition of Drought Stress at Three Different Growth Stages**.

Publications

Baroowa, B., Gogoi, N., Paul, S. & Sarma, B. (2012). Morphological responses of pulse (*Vigna* spp.) crops to soil water deficit. *Journal of Agricultural Sciences,* 57(1), 31-40.

Baroowa, B. & Gogoi, N. (2013). Biochemical changes in two *Vigna* spp. during drought and subsequent recovery. *Indian Journal of Plant Physiology*, 18(4), 319-325.

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Lowry, O.H., Rosebrough, N.J., Farr, A.L. & Randall, R.J. (1951). Protein measurement with the Folin phenol reagent. *Journal of Biological Chemistry,* 193(1), 265-75.

Mnivannan, P., Jaleel, C.A., Sankar, B., Kishorekumar, A., Somasundaram, R., Alagu Lakshmanan, G.M. & Panneerselvam, R. (2007). Growth, biochemical modifications and proline metabolism in Helianthus annuus L. as induced by drought stress. *Colloids and Surface B: Biointerafacs,* 59, 141–149.

Singh, S., Gupta, A.K. & Kaur, N. (2012). Differential responses of antioxidative defence system to long-term field drought in wheat (*Triticumaestivum*L.) genotypes differing in drought tolerance. *Journal of Agronomy and Crop Science,* 198(3), 185-195.

Annexure-III

UNIVERSITY GRANTS COMMISSION

BAHADUR SHAH ZAFAR MARG

NEW DELHI-110002

STATEMENT OF EXPENDITURE IN RESPECT OF MAJOR RESERCH PROJECT

1. Name of Principal Investigator : Dr. Nirmali Gogoi

2. Deptt. Of Principal Investigator : Environmental Science

University/College : Tezpur University

3. UGC approval Letter No. and Date : F.No.39-316/2010 (SR) dated 27/12/2010

4. Title of the Research Project : "Impact of climate change with reference to low rainfall on sustainable" productivity of pulse crops in Assam"

5. Effective date of starting the project : 10/05/2011

6. a. Period of Expenditure : From 10/05/2011 to 9/05/2014

b. Details of Expenditur

30/3/17

Finance Officer
Tezpur University

Details of Expenditure

Head	Fund received (Rs.)		Total (Rs.) A	Expenditure (Rs.)			Total (Rs.)	Balance (Rs.) A-B
	1st Instalment	2nd Instalment		I 2011-12	II 2012-2013	III 2013-14	(I+II+III)=B	
Books and Journals	25000	-	25000	Nil	15758	8271	24029	
Equipment	260000	-	260000	Nil	247408	7378	254786	
Contingency		30000		30970	-	100	31070	
Travel/Field work		40000		30657	-	26650	57307	
Hiring services	327800	Nil	721154	-	-	-	-	
Chemicals and Glassware		40000		30005	19030	40965	90000	
Overhead		-		46300	-	-	46300	
Man power (Fellowship)		283354		77677	64000	386323	528000	
Total (Rs.)	**612800**	393354	1006154	215609	346196	469687	1031492	
Interest earned (Rs)	25338							
Total (Rs)	1031492						1031492	NIL

1. It is certified that the appointment (s) have been made in accordance with the terms and conditions laid down by the Commission.

2. If as a result of check or audit objection some irregularity is noticed a later date , action will be taken to refund, adjust or regularize the objected amounts.

3. Payment @ revised rates shall be made with arrears on the availability of additional funds

4. It is certified that the grant of Rs.1006154 (Rupees ten lakhs six thousand one hundred fifty four only) received from the University Grants Commission under the scheme of support for Major Research Project entitled "Impact of climate change with reference to low rainfall on sustainable productivity of pulse crops in Assam" vide UGC letter No. F. No.39-316/2010 (SR) Dated27/12/2010 and an amount of Rs. 25338 (Rupees Twenty five thousand three hundred and thirty eight only)has been earned as interest during the period. An amount of Rs. 1031492 (Rupees Ten lakhs thirty one thousand four hundred ninety two only) has been fully utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grants Commission.

SIGNATURE OF THE PRINCIPAL INVESTIGATOR

REGISTRAR/PRINCIPAL

Registrar
Tezpur Univer...

Annexure -V

UNIVERSITY GRANTS COMMISSION

BAHADUR SHAH ZAFAR MARG

NEW DELHI-110002

Utilization Certificate

It is certified that the grant of Rs.1006154 (Rupees ten lakhs six thousand one hundred fifty four only) received from the University Grants Commission under the scheme of support for Major Research Project entitled "Impact of climate change with reference to low rainfall on sustainable productivity of pulse crops in Assam" vide UGC letter No. F. F. No.39-316/2010 (SR) Dated27/12/2010 and an amount of Rs. 25338 (Rupees Twenty five thousand three hundred and thirty eight only)has been earned as interest during the period. An amount of Rs. 1031492 (Rupees Ten lakhs thirty one thousand four hundred ninety two only) has been fully utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grants Commission.

SIGNATURE OF THE	REGISTRAR/PRINCIPAL	STATUTORY AUDITOR
PRINCIPAL INVESTIGATOR	*Registrar* *Tezpur University*	*Finance Officer* *Tezpur University*

30/3/17

For SURAJIT CHAKRABORTY & CO.
CHARTERED ACCOUNTANTS

04.04.2017

A SURAJIT CHAKRABORTY
(Proprietor)
Membership No.- 306854