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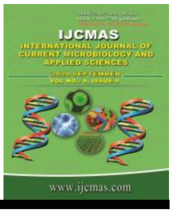

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Non Structural Carbohydrate Accumulation in Plant Parts of Rice Genotypes Grown under Drought and Open Field: A comparative Study

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ABSTRACT

The present study was carried out in sixteen genotypes having different aptitude for tolerance to stress. Drought stress was imposed at early reproductive phase of growth. Despites of reduction in plant height and number of tillers, genotypes have shown least reduction in the grain yield under drought stress. Interestingly, genotypes like Sabour Sampann, Sabour Ardhjal and BRR-0028 showed higher adaptive responses with least reduction in plant height of less than 10% under drought than open field. Also, the number of tillers in BR-0028 and BRR-0063 were remained same in both the situation suggesting specificity of genotypic responses. Moreover, genotype BRR-0028, Sabour Sampann and Sabour Ardhjal showed higher yield retention with least reduction in the yield of only 25%, 30% and 31% respectively under drought stress. It implied the persuasion of accumulated CHO at unambiguous phase of growth period. CHO accumulated higher in leaf sheath (176.5 mg^{-1} g fresh wt) at 45 days of growth which gradually decreased (93.29 mg^{-1} g fresh wt) with increasing days in genotype Sabour Ardhjal at 75 days of growth. The same genotype revealed alter CHO accumulation in plant parts with highest in Culm (83.38 mg^{-1} g fresh wt), three fold higher than the leaf blade and leaf sheath during drought stress. The result also supported by the higher LAI/LAD during the early reproductive phase between 45 to 60 days of growth and suggested to explicit longer period for assimilates accumulation and sink development for better grain yield in rice under reproductive drought.

Keywords

Rice, drought stress, Non structural carbohydrates, Grain yield, Growth parameters

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Introduction

In agriculture, many abiotic stresses are the major constraint that affected the yield of crops. Amongst all, drought is the most serious stress for rice which deteriorates the rice yield production. Global climate change affects a variety of factors associated with drought and extreme drought land area is likely to increase from 1-30 % by 2100 (Lijuan Miao *et al.*, 2015). In Asia, around 130 million ha of paddy are annually affected by drought, thus limiting rice production worldwide (Rajiv *et al.*, 2010; Rahimi *et al.*, 2013). About 42% of India's land area is facing drought, with 6% exceptionally dry-four times the spatial extent of drought last year, according to data for the week ending

March 26, 2019, from the Drought Early Warning System (DEWS), a real-time drought monitoring platform. The state like Bihar with 60% to 70% of cultivation is dependent on rainfall, any deviation, especially any deficit, is bound to impact production, particularly rice cultivation in the Kharif.

Drought has been identified as the single most critical threat to the world food security (Farooq *et al.,* 2009), and one of major factors inhibiting physiological activities such as photosynthesis, decreasing growth and crop loss, reducing average yields for most major crop plants by more than 50 to 60 % (Bray *et al.,* 2000; Wang *et al.,* 2003). Report also added, this significant lost in the yield is due to significant restriction in plant growth and development. Yield loss, induction of oxidative stress with loss of membrane integrity, semi-permeability, electrolyte leakage, loss in pigment content, decreased photosynthesis activity, alteration in osmotic adjustment water relation are commonly described responses of drought stress.

Plants intervention to drought stress is vast and immensely depends upon intensity and duration of stress as well as plants developmental stages. Plants undergo various morphological, physiological and biochemical changes upon drought stress, such changes become imperative to crop adaptation at specific developmental stage. Many reports revealed crop tolerant towards drought stress through various plant growth components. Despites of all adaptive response crops sometime failed to give better yield performance. However, in agriculture the key constituting element under stress is not only plant adaptation but its grain yield. Report also showed the relevance of effectual tolerant traits for grain yield rather than tolerant attributes alone (Nahakpam, 2017).

Moreover, besides being crops varietal disparity, every plant organ is ideally participated to fulfil metabolic and physiological processes in specific environmental conditions. Generally, for various physiological attributes, studies were carried out focusing on flag/or first leave. However, recent reports give a cross-talk on role of individual leave and its response towards temperature, light and other abiotic stress. Physiological responses such as photosynthetic rate of flag leaf were seemingly involved to stress tolerant attribute rather than contributing in grain yield for early reproductive drought stress in rice. This uncertainty of photosynthetic activities results in less photosynthate translocation to sinks. And so, under stress, plant growth (Xu and Huang, 2000; Nahakpam, 2017a and 2017b) and grain filling (Yang and Zhang, 2006) become more dependent on remobilized reserves that might have translocated from lower leaves.

In cereal crops, the contribution of stored non structural carbohydrates (NSC) to the grain yield can be more than 50% under stress conditions, but it is 5-33% in non-stress conditions (Hirano *et al.,* 1998; Wardlaw and Willenbrink, 2000; Zhang *et al.,* 2009). These results were observed in vegetable crops like potato and cereal crops like wheat, suggesting that culm and leaf reserves might act as a short-term buffer to maintain the supply of photosynthate to developing organs when the supply of photosynthate from source leaves cannot satisfy the requirement of sinks (Wardlaw and Willenbrink, 2000).

Therefore, an increasing evidence for considerable interlinking about contrasting responses with various crops yield is much at cross-talk. In previous findings on rice genotypes having partial tolerant attributes showed non-significant positive correlation of photosynthesis with grain yield. Further on investigation has revealed a half way result that under reproductive drought, grain yield are more seemingly dependent on the lower leaves and culm reserve rather than the flag leaves. This result has also been supported by more chlorophyll stability in the third leaves with less reduction of the content. Zhang *et al.*, (2009) workers have also mentioned undoubtedly the involvement of stem reserves and its translocation towards the grain under stress situation.

Earlier in rice crop, from the initiation of panicle primordia to around heading, involvement of five leaves that are functioning has also been discussed by Yoshida (1981). Diverse reports on carbohydrates reserve were analysed in wheat (Virgona and Barlow, 1991), potato (Zhang, *et al.*, 2009), horticultural fruits (Hassan *et al.*, 2017). In rice, it is also stated total reliance of grain filling and rice yield on the efficient transport of carbohydrates from the leaves reserve to seeds (Wang *et al.*, 2015). Therefore, understanding the accumulation and distribution of carbohydrates to facilitate better grain yield in rice under water stress condition is a prerequisite.

Materials and Methods

Experimental site and plant materials

Experiments were carried out in sixteen genotypes of 120 days maturity group having different potentials of stress tolerance. The experiments were laid in the Rice research farm of Bihar Agricultural University, Sabour. Seeds were sown directly in randomized block design under two conditions, one in rain out shelter (to induced drought stress) and second in an open field condition. Drought was imposed by withholding irrigation from 45 days of growth to induced reproductive stress and soil moisture content was measured using soil gravimetric method. Data were recorded at three distinctive growth phases: vegetative phase (45 days of growth), in early booting phase (60 days of growth), in flowering phase (75 days of growth). Standard cultural practices were carried out throughout the crop seasons and hand weeding was done from time to time. All the experiments were performed in triplicate.

Plant morphological observation and growth analysis

Under the morphological parameters Plant height, number of tillers per plants was observed. Leaf area was calculated by using the formula l x b x k, where l is the length of the leaf, b is the breadth of the leaf and k is the coefficient value that had been derived. Leaf area hill^{-1} was measured on the middle tiller as per the method given by Yoshida *et al.*, 1976. LAI and LAD were also measured and calculated using the given formula:

$$\text{LAI} = \frac{\text{Leaf area hill}^{-1}}{\text{Ground area}} \quad \text{and} \quad \text{LAD} = \frac{\text{L 1 + L 2 hill}^{-1}}{2} \times \text{T2} - \text{T1}$$

Where L 1 is LAI at the first stage; L2 – LAI at the second phase; T2 – T1 is the time interval in days

Non structural carbohydrate (CHO) determination

Plant samples were collected in the morning hour and immediately packed in the plastic bag. In the laboratory the plants were separated for Leaf blade, Leaf sheath and Culm. Thereafter, fresh samples were taken for estimation of total CHO using phenol-sulphuric acid and absorbance of the colour developed were recorded in 490 nm by method Dubois *et al.*, 1956, using glucose as standard. All the experiments were performed in triplicate.

Statistical analysis

Data were analyzed using Analysis of Variance (ANOVA) for the variables measured to test for significant differences.

Results and Discussion

Morphological responses and growth variability under drought and open field

Diversity in genotypic responses was observed in terms of plant height and number of tillers (Table 1). Reduction in plant height under drought stress were noticed in all the genotypes studied however genotypes HS4 and HS6 showed maximum decreased with almost 40% reduction in plant height (Table 1) as compared to other genotypes. The reduction in plant height under drought has been supported by the previous research reported by many (Singh *et al.*, 2018; Nahakpam 2017; Weng *et al.*, 2014). Nevertheless, plant morphological responses towards drought stress are also showed by reduction in the number of tillers was distinctively observed under drought stress ranges from 4 to 8 numbers as to that of plants grown in open field which ranged from 6 to 11.

Interestingly, genotypes like Sabour Sampann, Sabour Ardhjal and BRR-0028 showed higher adaptive responses with least reduction in plant height of less than 10% under drought than open field. Also, the number of tillers in BR-0028 and BRR-0063 were remained same in both the growing situation. Non significant decreased in plant height were also noticed amongst the genotypes revealing higher adaptive potential and least affected by drought stress. To retain stability under drought stress reduction in leaf area, leaf expansion is common responses of plants that directly affect yields (Anjum *et al.*, 2011; Hussain *et al.*, 2008).

However, maximum LAI and LAD at particular growth period are important traits that revealed the fate of plants grain yield (Devendra *et al.*, 1983; Lopez *et al.*, 1997). It further suggested that increased of LAD at later stage of growth period enhance biological yield but not the grain yield in rice. The present study of Leaf area at different days of growth (45 days, 60 days and 75 days) was recorded and LAI of respective intervals were calculated (Table 2). LAI reductions are more in the drought exposed plants from the open field plants. However, genotypes BRR-0028, HS2, HS6 and Sahbhagi Dhan showed higher LAI ranging from 2.9 to 5.18 at 60 days of growth under drought from that of open field. Amongst the days of growth there were increased in LAI on 60 days from 45 days and again decreased when it went to 75 days but a gradual increased in LAI with increasing days of growth in the genotypes Sabour Ardhjal (3.47, 3.75, 4.97) had been recorded under drought. Similar, increased in LAI value with increasing days of growth period had also been noticed in the genotypes HS5, BRR-0054, BRR-0057, BRR-0063 under drought stress.

LAD of genotypes grown in open field showed longer duration ranged from 30 to 58 days in the second interval of 60-75 days than first interval of 45-60 days except in genotype HS4 (Table 2). LAD of genotypes grown under drought revealed maximum LAD in the first phase of interval between 45-60 days of growth and ranged from 31 to 60 days in the genotypes HS2 and Sahbhagi Dhan respectively. Our research findings also showed clearly that all the genotypes had longer days of LAD at 45 to 60 days of growth period with 54 to 60 days duration under drought (Table 2) and has positive correlation with grain yield (data not shown).

Table.1 Variation in the plant height and number of tillers at 60 days of growth affecting grain yield under drought and open field

Genotypes	**Plant height (cm)**		**Number of tillers**		**Yield Kg/ha**		**% Decreased in grain yield**
	Open Field	Drought	Open Field	Drought	Open Field	Drought	
Sabour Ardhajal	101.2	73.8	8	6	6236	4271	31.51
BRR-0028	106.6	95.6	6	6	6366	4723	25.81
Sabour Sampann	97.1	90	6	5	7284	4252	41.63
Sabour Surbhit	99	91	10	7	6543	3727	43.03
BRR-0054	100.2	76	7	5	6761	4240	37.29
BRR-0057	97.7	87	6	5	7213	4173	42.15
BRR-0063	100	77	8	8	7011	4107	41.42
BRR-0078	101	86	10	6	7083	4000	43.53
MTU-10	102	94.4	6	5	7306	4283	41.38
HS1	99.3	83.5	6	5	6989	4213	39.72
HS2	108	78.5	11	6	6951	4230	39.15
HS3	97.4	82	9	7	7701	3973	48.41
HS4	100	62	8	4	7089	4780	32.57
HS5	94	79	8	6	6842	4261	37.72
HS6	102	63	6	5	7203	4364	39.41
Sahbhagi Dhan	91	76	7	5	7504	5187	30.88

Table.2 Growth analysis parameters: Leaf area, Leaf area index (LAI) and Leaf area duration (LAD) of rice grown in drought and open field

Growth period	**Leaf area Index (LAI)**						**Leaf area duration (LAD)**			
	Open Field			Drought			Open Field		Drought	
Genotypes	45 days	60 days	75 days	45 days	60 days	75 days	45 -60days	60 -75 days	45 -60days	60 -75 days
Sabour Ardhajal	3.52bc	5.26a	3.86bc	3.47b	3.75bc	4.97a	55.88a	58.43a	54.19ab	55.64a
BRR-0028	3.26c	3.41c	3.80bc	3.63b	4.11b	3.85b	37.57c	49.09b	58.09a	52.27ab
Sabour Sampann	4.33a	4.21b	3.36d	2.09d	3.15c	2.52c	46.57b	51.75a	54.32ab	47.50b
Sabour Surbhit	2.95cd	3.85bc	3.92b	2.05d	3.00c	2.44d	34.45c	33.24c	32.91d	25.83d
BRR-0054	2.41d	3.83bc	4.54a	2.13d	3.46c	3.97a	31.78c	32.76a	41.91c	55.69a
BRR-0057	2.98c	3.45a	3.66c	2.41d	3.36c	3.94a	38.17bc	45.79b	35.82d	32.27cd
BRR-0063	3.02cd	3.48c	3.74c	2.49c	2.92d	3.41b	38.75bc	44.15b	33.07d	32.49cd
BRR-0078	3.20c	4.25b	3.76c	2.95b	3.85bc	3.60b	35.85c	37.09c	56.95ab	55.82ac
MTU-10	3.12c	5.63a	4.59a	2.19d	3.25c	3.73b	35.60c	39.12c	55.76ab	37.34c
HS1	3.26c	3.55c	3.57d	2.44c	2.53d	2.13e	32.02c	43.41b	37.24cd	34.91c
HS2	3.07cd	3.26	4.21b	2.76bc	3.46c	2.41d	34.99c	38.59c	31.65d	21.51d
HS3	2.55d	3.59c	3.46c	2.55c	3.12cd	2.22e	43.58b	30.36d	42.55c	40.08b
HS4	2.12d	2.65d	3.25d	2.02d	3.55c	3.09b	35.77c	36.75c	47.81b	42.30b
HS5	3.29c	4.14b	4.54a	2.78bc	3.84bc	3.91a	35.74c	37.63c	37.13	34.12c
HS6	2.04d	3.89bc	3.25	3.78a	4.29b	3.37bc	44.44b	53.58a	55.51ab	49.94ab
Sahbhagi Dhan	3.98b	4.70b	4.92a	3.94a	5.18a	4.76a	40.15bc	47.20b	60.94a	59.58a

Values with different alphabets are significantly different at $P \leq 0.05$

Table.3 Changing patterns of CHO accumulation (mg^{-1} g fresh wt) in different plant parts of rice Leaf blade, Leaf Sheath, Leaf culm and grain grown of rice genotypes grown in an open field

Growth period / **Genotypes**	**45 days**			**60 days**			**75 days**			**Grain**
	Leaf blade	Sheath	Culm	Leaf blade	Sheath	Culm	Leaf blade	Sheath	Culm	
Sabour Ardhajal	106.56d	176.5a	78.81d	91.02b	94.35d	71.04e	86.58de	93.29c	67.73d	253.1a
BRR-0028	97.92d	138.75c	95.46c	89.89c	104.36c	73.26e	86.63de	92.17c	56.63e	167.6cd
Sabour Sampann	131.04a	162.16b	112.11b	82.14cd	104.34c	86.58d	81.07e	111.08b	84.41b	169.8cd
Sabour Surbhit	114.27c	129.92d	94.37c	97.72b	114.33b	89.91d	147.63b	127.75a	84.84b	125.4e
BRR-0054	96.57d	118.71e	91.02	95.41bc	115.02b	95.46c	76.39f	109.05b	91.08a	85.47f
BRR-0057	106.56d	118.81e	104.34bc	96.57b	114.36b	102.12b	87.74de	91.05c	85.52b	162cd
BRR-0063	76.59f	118.47e	88.8d	77.7d	113.22b	75.48e	78.85f	93.96c	76.61c	136.6de
BRR-0078	74.37ef	97.48	92.13c	87.69c	115.44b	99.9c	89.97de	98.86c	94.41a	136.5de
MTU-10	124.32b	169.88ab	98.84c	121.02a	92.14d	98.82c	87.73de	83.41d	63.63d	173.2c
HS1	135.42a	139.86c	68.82e	97.7b	111c	85.47d	95.53c	93.27c	76.6c	178.7c
HS2	77.7e	125.43d	103.2c3	95.46bc	87.69d	74.37e	93.31c	86.61d	72.18c	196.57b
HS3	89.91e	113.22e	130.98a	85.46c	95.6c	99.9c	152.07a	96.62c	96.6a	96.57f
HS4	106.56d	133.2c	75.48d	88.8c	117.66b	58.83f	87.71de	98.86c	72.15c	181c
HS5	88.8d	128.03d	119.88b	89.91c	77.7e	89.91d	107.57c	78.82e	81.07b	147.7d
HS6	113.75c	138.22c	73.26d	79.92d	89.91d	79.92e	92.2d	82.97d	84.39b	157.6d
Sahbhagi Dhan	139.86a	141.02bc	121.02ab	95.46bc	145.46a	122.1a	87.72de	98.83c	95.5a	148.7d

Values with different alphabets are significantly different at $P \leq 0.05$

Table.4 Changing patterns of CHO accumulation in different plant parts of rice Leaf blade, Leaf Sheath, Leaf culm and grain of rice grown in drought situation

Growth period / Genotypes	45 days			60 days			75 days			Grain
	Leaf blade	Sheath	Culm	Leaf blade	Sheath	Culm	Leaf blade	Sheath	Culm	
Sabour Ardhajal	56.61e	65.63c	69.05d	63.653e	77.69d	84.38c	74.37b	75.52c	79.92c	178.8a
BRR-0028	48.84f	74.4b	86.63a	73.22d	89.9bc	79.01d	74.36b	79.92bc	82.15b	125.4de
Sabour Sampann	73.26c	83.29ab	72.18c	81c	69.88e	75.83d	69.92c	74.36c	79.92c	113.2ef
Sabour Surbhit	72.15c	77.74b	77.72bc	115.44a	75.48d	79.9d	99.9a	103.23a	66.61d	98.6f
BRR-0054	51.06e	71.08b	74.73c	83.25c	86.56c	88.79b	77.7b	73.26c	43.29e	66.6f
BRR-0057	78.86bc	68.85c	77.74bc	79.92d	81.03c	92.13ab	74.35b	69.93d	76.59c	135.5d
BRR-0063	68.82	76.64b	86.63a	88.8c	79.92d	87.69b	68.81c	76.59bc	79.48c	164.3bc
BRR-0078	58.83e	61.08c	83.28a	92.11b	93.24b	96.57ab	76.59b	85.47ab	164.28a	127.7de
MTU-10	52.17e	64.42c	78.84b	97.68a	91.02b	92.94b	82.14ab	81.03b	73.26c	137.6d
HS1	53.28e	45.51d	53.3e	107.67a	105.45a	91.02b	89.91ab	39.96f	86.58b	151bc
HS2	52.17e	49.95d	66.6d	104.34a	91.02b	108.78a	86.58ab	46.62e	74.25c	170.9b
HS3	89.95a	92.16a	96.61a	78.76d	98.79b	89.91b	74.37b	71.04cd	74.37c	136.5d
HS4	78.84bc	69.96c	79.94b	74.37d	67.69e	84.38c	67.71c	77.7bc	73.26c	126.58de
HS5	85.5b	75.53b	81.03a	96.57b	93.24b	101.01a	77.7b	76.62bc	78.26c	118.8e
HS6	94.41a	86.6a	76.64c	91.33b	75.8d	77.69d	77.7b	73.26c	77.92c	144.3cd
Sahbhagi Dhan	65.49d	32.19e	54.39e	99.9a	88.8c	102.12a	83.25ab	78.81b	84.36b	122.1de

Values with different alphabets are significantly different at $P \leq 0.05$

An increase in plant leaf area even under drought stress is defined as a function of growth habit differences on leaf growth that determines the light interception capacity of a crop thus resulted in an increase in dry matter production (Weraduwage *et al.*, 2015; Lopez *et al.*, 1997). Increased LAI and LAD under drought at early stage is a result of earlier and more rapid leaf production in the vegetative growth phase and promote longer period for sink development and thus the grain yield (Cabrera-Bosquet *et al.*, 2011; Yoshida & Ahn 1968; Devendra *et al.*, 1983).

Non structural CHO accumulation in different parts of plants under drought and open field

Table 3 represents the patterns of accumulation and distribution of CHO in different parts of the plant at three phases of growth period. CHO accumulation was estimated on leaf blade, leaf sheath and culm at different days of growth and results revealed that Total CHO accumulation was decreased with increasing days of growth in open field condition. Accumulation of CHO in different part of plants showed maximum in leaf sheath than that of leaf blade and culm in all the period. Maximum accumulation of CHO in the grain was observed in the genotype Sabour Ardhjal with 253.1 mg^{-1}g fresh wt and lowest accumulation was noted in the genotype BRR-0054 with 85.47 mg^{-1}g fresh wt. Moreover, highest leaf sheath accumulation of CHO was in the genotype Sabour Ardhjal with 176.5 mg^{-1}g fresh wt and followed by the genotype MTU-10 (169.88), Sabour Sampann (162.16), Sahbhagi Dhan (141.02), HS1 (139.86) and BRR-0028 (138.75) mg^{-1}g fresh wt respectively at 45 days of growth.

However, the accumulation pattern of CHO under drought exposed plant showed variation amongst the genotypes with increasing days of growth and accumulation was found to be highest in the culm as compared from that of leaf sheath and leaf blade (Table 4). In contrast from the open field genotypes in drought stress showed higher accumulation of CHO in 60 days and 75 days than 45 days of growth. Also, accumulation of CHO in plant parts were shown highest in culm with 86.58 mg^{-1}g fresh wt (HS1) followed by in genotype Sahbhagi Dhan with 84.36 mg^{-1}g fresh wt and 79.92 mg^{-1}g fresh wt in Sabour Ardhjal and Sabour Sampann at 75 days of growth. Under drought stress, grain accumulation of CHO was observed highest in the genotypes Sabour Ardhjal (178.8 mg^{-1}g fresh wt), HS2 (170.9 mg^{-1}g fresh wt) and BRR-0063 (164.3 mg^{-1}g fresh wt) respectively. The least grain accumulation of CHO was noticed in genotype BRR-0054 with 66.6 mg^{-1}g fresh wt in similar pattern as grown in the open field.

Grain yield and CHO contribution rate in the grain under drought and open field

Genotypes grain yields ranged from 7504 kg/ha to 6143 5g/ha in genotypes Sahbhagi Dhan and Sabour Surbhit respectively under open field conditions whereas 5787 kg/ha and 3757 kg/ha were noted in the same genotypes under drought stress (Table 1). Grain yield reduction under drought stress was observed to be genotypic specific and varies in the value with the decreasing percent ranged of 25.81 (BRR-0038) to 48.41 (HS3). Others genotypes showed almost at the average decreased % of 35 to 43 under drought stress as compared from grain yield in open field (Table 2).

Reduction in the accumulation percent of CHO under drought stress was distinctive in different parts of the plant including in grains (Table 4). Insignificant increased percent of CHO accumulation in Culm of few genotypes at 60 days and 75 days were observed under drought from that of open field condition.

However, genotype BRR-0078 (74.04%) and BRR-0028 (45.06%) had shown a significant increased in percent in Culm at 75 days of growth. As far as CHO accumulation in grain is concerned, genotype HS3 revealed 41.35% increased in drought stress (Table 4).

Grain yield is much affected by drought stress and reduction of yield almost upto 50% in genotype HS3 (Table 1). However, retention of grain yield in few other genotypes such as BRR-0028, HS1, HS4 are less as compared to the open field grown plants. Result is an indication to the plants photo-assimilates accumulation capability at specific growth period. Longer period for sink development influence by the higher LAI and LAD at 45 days to 60 days duration is also one of the biggest reasons in contribution to final grain yield. Role of NCS in final grain yield is tremendous, about 85% of CHO (mainly starch) form in the grain is due to assimilates supplied by the early growth stage and it is contributed by differential accumulation in different part of the plants (Yoshida, 1981; Zhang *et al.,* 2016, Miyake, 2016). Every plant organ ideally participates to fulfil metabolic and physiological processes in specific environmental conditions (Moura *et al.,* 2017).

Rice plant comprises of leaves that are physiologically different in age and activity. At early stages of leaf growth, increases in plant biomass are associated with elongation. After completion of elongation, the weight continues to increase because of an accumulation of proteins and starch and for future developmental stages, thus suggesting the importance of accumulated reserve foods in plant development. Also, different growth parameters such as leaf area index, leaf area duration, dry matter accumulation and crop growth rate are influenced significantly influenced by all the competition durations (Yoshida, 1981).

The study suggested the genotypic potential in accumulation of CHO at leaf blade, leaf sheath and Culm. During drought stress accumulation of CHO are higher in Culm from leaf blade and leaf sheath (Table 4). This result has been supported by Pandey and Shukla (2015) and suggesting the decreased of photosynthesis at the same site causing feedback inhibition.

Therefore increased accumulation of CHO in Culm and to continue increase more till 75 days of growth might be the explanation of Culm contribution in stability and increased of grain yield. It also implied to the importance of growth period Wang *et al.,* (2015) study on transgenic high yielding rice reported that grain filling was accelerated at particular stages of growth duration.

This acceleration in grain filling is generally due to continuous supplication of photo assimilates which has been transported from the lower leaves to the grain. It implied to the improvement in rice yield by increasing grain size with maximum sucrose loading and seed development depends on the accumulation of sugars and storage protein during grain filling (David *et al.,* 2014) and maximizing apparent contribution rate of CHO in grain yield is depend on the prolonged accumulation potential in both the early and later phase of drought.

Participation of non structural CHO accumulation at particular growth period alter CHO accumulation amongst the part of plant, whereby Culm having shown maximum CHO accumulation aptitude for early reproductive drought stress rather than the leaf blade and leaf sheath.

Result has also provided an insight to unravel the involvement of different leaves translocation of CHO to sink for better grain yield under reproductive drought stress.

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Conflict of interest

All the authors have contributed equally

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