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GHG EMISSION REDUCTION FROM WETLAND PADDY FIELD

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Introduction

Natural shifts in global temperature had occurred throughout human history in the past. The Fourth Assessment Report Working Group I (WG1) of the Intergovernmental Panel on Climate Change (IPCC, 2007a) concluded that 'Warming of the climate system is unequivocal' and that discernible human influences now extended to other aspects of climate including ocean warming, change in continental-average temperature, occurrence of temperature extremes and change in wind patterns. The report also assessed the likely range of future climate that happen. The Working Group II (WGII) report (IPCC, 2007b) documented that the impact of climate change is already being observed based on 75 studies with some 20,000 observations documented on physical and biological systems.

The IPCC predicted that the pace of climate change was 'very likely' (> 90 per cent probability) to accelerate with continued GHG emission at or above current rates, with globally averaged surface temperatures estimated to rise by 1.8°C to 4.0°C by the end of the 21st century. Changes in temperatures and other climatic features would vary globally (IPCC 2007b). Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) were important drivers of this anthropogenic greenhouse effect.

GHG emission from agriculture:

Agricultural practices release significant amount of greenhouse gases (GHGs) like carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), which play a vital role in global warming and its related climate change. The Intergovernmental Panel on Climate Change (IPCC) reported that the atmospheric CO_2 would rise from current concentration of 381 to 550 ppm by 2050 (Yang, 2009). Agriculture accounts for 10 to 12 per cent of total global anthropogenic emission of GHG.

According to a report of Indian Network for Climate Change Assessment, the major sources in the agricultural sector are enteric fermentation (63.4 per cent), rice cultivation (20.9 per cent), agricultural soils (13.0 per cent), manure management (2.4 per cent) and on-field burning of crop residues (2.0 per cent). Agricultural soils especially rice soils with continuous submergence up to six months contribute towards the emission of CH_4, N_2O and CO_2.

The rising demand for food commodities including rice also causes increasing pressure on agriculture and consequently on the climate system. It is therefore, pertinent to develop technologies to reduce emission of GHGs from agriculture. This will not only postpone climate change but also reduce the consumption of costly inputs by enhancing their use efficiency and

increase farmers income. The rice fields are a major source of CH_4 and emit N_2O emissions as well. Global CH_4 emission estimates from paddy ranges from 29 to 61 Tg/yr. Rice cultivation has been noted globally as a GHG emitter.

Methane emission and mitigation – rice field:

CH_4 had a global warming potential of about 25 relative to CO_2 and responsible for approximately 25 per cent of the anticipated warming. The biogenic CH_4 is mostly produced from the anaerobic decomposition of organic compounds by Methanogenic archaea under highly reduced rice soil conditions, where CO_2 acts as inorganic electron acceptor.

Since flooding creates anaerobic conditions that favours the growth and multiplication methanogens direct sowing of rice, rainfed and aerobic cultivation reduces methane emission. Also System of Rice Intensification (SRI) reduces the emission of methane by 40-50 percent when compared to that of conventional flooded system.

After flooding of rice field soils, common electron donors such as acetate and hydrogen are present in excess for anaerobic respiration and methanogenesis occurs, in parallel to iron and sulfate reduction. When electron donors for microbial respiratory processes become limiting methanogenesis could be suppressed by supplementing alternative electron acceptors such as ferric or sulfate, which may result a combination of inhibition effects and competitive effects with different microorganisms for the common electron donors. The mechanism behind this could be the competition between CH_4 producing bacteria (methanogens) and sulfate reducing bacteria for the same substrate. The application of neem coated urea, coated calcium carbide, neem oil and dicyandiamide (DCD) reduce the emission of methane by suppressing microbial activities. Application of sulphate-containing amendments is a mitigation option for reducing CH_4 emission from rice fields.

Some of the possible mitigation and adaptation strategies to minimize the global warming potential of rice fields are

i. Water management.
ii. Direct seeding.
iii. Choice of chemical fertilizers, method and time of application and soil amendments.
iv. Use of different rice cultivars.
v. Improved tillage and crop residue management practices.
vi. Use of Phytosynthetic Blue Green Algae in rice cultivation.
vii. Dual cropping of azolla in rice.

Nitrous oxide emission and mitigation:

Nitrous oxide is primarily produced by microbial processes in the soil. Nitrous oxide also participated on the destruction of stratospheric ozone in addition to its role as GHG. Three sources of N_2O were direct emission from agricultural soils, emission from animal production and emission indirectly induced by agricultural activities.

Agricultural anthropogenic sources of N_2O emission were proved to arise from fertilization of soils with mineral N, fertilization with animal manures, N derived from biological N fixation, N from atmospheric deposition and N from enhanced soil N mineralization.

In conventional cropping systems, N_2O emission was generally lower in organic cropping systems, while some other studies showed that N_2O emission could be significantly different or greater from organically farmed soils relative to conventionally farmed soils and N_2O emission could be mostly produced in upland fields and also pronounced as a result of the mid season drainage and dry–wet episodes in paddy fields.

Improving the efficiency of N can reduce emission of N_2O from rice fields. Nitrogen applied through fertilizers and manures is not always used efficiently by crops. Practices that improve N use efficiency include slow-release fertilizer like neem treated urea, coal tar treated urea, urea super granules could reduce the emission of nitrous oxide from the rice fields even under unflooded conditions.

Conclusion:

The emission of the GHG from rice field could be reduced by integrated approaches so that it does not compensate the rice productivity. Increasing the water and fertilizer use efficiency also increases the yield and reduces the methane and nitrous oxide emission from the rice field. Environmental sustainability should also be considered along with the increasing the productivity.

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MORINGA: A MIRACLE TREE FOR SUSTAINABLE AGRICULTURE

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In agriculture chemical fertilizers used most frequently than organic fertilizers. This is mainly because their result is faster and plants absorb and utilize them quicker. This lead too many issues for environment and human health such as ground water contamination, soil erosion and degradation issues, chemical residue in food and other. Hence there is a need to protect environment by promoting organic agriculture. In this one of the option is to use of organic products to improve yield and quality of the agriculture produce. Moringa leaf extract as foliar spray is can be used (bio stimulant) to improve the quantity and quality of the produce.

Moringa leaves are source of vitamins, carotenoids, anti-oxidant substances and trace elements (Michaul *et al*., 2008) and rich in mineral elements P, Ca, K, Mg, Fe, Cu, Zn & Mn (Merwad, 2018) Moringa leaves good source of gibberellins, cytokinin, IAA and zeatin (Lathif and Mohamed, 2016). Unuigbe *et al*. (2015) noticed that, moringa leaves contain zeatin *i*.e. plant growth hormone. By using moringa leaf extract yields of soybean, maize and coffee can be improved by 25-30%. Moringa leaf extract is used as an effective plant growth hormone to enhance seed germination, improving yield and growth in plants (Phiri, 2010). Because of having antioxidant compounds like zeatin, ascorbic acid, phenolic flavonoids, vitamin E and minerals in moringa leaves, it can be used to enhance the metabolism of plants and overcoming plants from environmental stress (Lathif & Mohamed, 2016).

Manzor *et al*. (2015) the concentration of 5% leaf extract (MLE) and root extracts significantly increased growth and reduced aphid infestation in wheat crop, as well as improved leaf area index, total dry matter, growth rate, spike numbers, and the total yield. Moringa leaf extract is also used as a growth promotor in seed germination of many cereal crops like sorghum, rice, wheat & maize (Chattha *et al*., 2018). Mathew (2016) found that growth and yield of pepper increased with the spray of 5% concentration of moringa leaf extract. Higher protein content and fresh pod weight in pea plants was recorded with foliar application of 4% moringa leaf extract (Merwad, 2018). Moringa seed extract can be a useful source of antimicrobial property (Ali *et al*., 2004) Moringa leaf extract can be used as a safe and effective insecticide against weevil (Tshimenga *et al*., 2018). Foliar application with moringa leaf extract improves the immune system of plants against some parts and diseases (Makkar & Becker, 1996). Moringa leaf, seed or root extract can be used as a part of organic farming to improve human health as well as ecological balance.

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POTENTIAL OF STEM WATER SOLUBLE CARBOHYDRATES(WSC) AS STEM RESERVES (FOR WHEAT GRAIN FILLING UNDER HIGH TEMPERATURE STRESS

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Abstract:

The changes in climate parameters are being felt globally in the form of changes in temperature and others. Some studies indicate a probability of 10-40 % loss in crop production in India with increase in temperature by 2080-2100 (Aggarwal, 2008). Global warming is causing frequent rise in ambient temperature rapidly for last two decades. The increased temperature during grain formation and filling phase of crop growth has emerged as a serious problem all over the world. The grain-filling rate of wheat, like other cereals, depends largely on leaf photosynthesis and water soluble carbohydrates (WSCs) transported to the grain from leaves, stem and ear reserves. The present study entitled potential of water soluble carbohydrates for grain filling under high temperature stress in wheat was carried out during *rabi* 2017. Two genotypes with two checks were grown in field conditions with varying sowing dates viz., 21st November 2016 (D_1), 21st December 2016 (D_2) and 21st January 2017 (D_3) and stem WSCs were analyzed for every week from anthesis till physiological maturity. Results clearly revealed that the WSC of terminal node (apical) and peduncle contributes significantly to the grain filling. Genotypes *viz*., NIAW-3033 and NIAW-1994 (Phule Samadhan) were found to be more efficient in mobilizing WSCs for grain growth.

Key Words: Water soluble carbohydrates, temperature stress, grain filling, wheat

1. Introduction

Wheat (*Triticum aestivum* L.) is the world's most outstanding crop that excels all other cereals both in area and production, known as king of cereals. It is also one of the most nutritious cereals and its contribution to human diet puts it in the top rank of plants that feed the world. Wheat accords a premier place among cereals because a vast acreage of land is devoted to its cultivation. Considerable efforts have been made to understand the factors controlling grain filling and grain weight in wheat in recent years. In addition to sink capacity, the supply of assimilates for developing grain determines its weight**.** Stress due to high-temperature has emerged as a major constraint for the successful wheat production worldwide (Hays *et al*., 2007; Kumar *et al.,* 2012a, b). Yield loss of 29 % is expected by 2080 due to global warming, in wheat. High temperature (>30°C) at the time of grain filling is one of the major constraints in increasing productivity of wheat in tropical countries like India (Zhao 2007). It has been reported that single grain mass falls by 3% - 5% for every 1°C rise in temperature above 18°C (McDonald 1983).

The production of new photosynthetic products may become limited under temperature stress, due to decrease in leaf stomatal conductance and net CO2 assimilation.

The supply of assimilates to the developing grain originates both from direct transport of current assimilation to kernels, and from the remobilization of temporarily stored assimilates in vegetative plant parts (Gebbing *et al.,* 1999). The individual grain weight is an important trait for increasing the yield potential of wheat (Xie *et al.,* 2015) and is generally reduced when plant experiences stress during grain filling.

Importance of stem WSC has been well established, however there are limited studies to explain the relative contribution of different internodes of stem for grain development. Hence this study was aimed to have an insight into the part of the stem that significantly contributing to the grain development of distinct wheat varieties developed at hot and dry southern peninsular zone of India. Leaf photosynthesis provides 90 to 95% of the carbohydrates in wheat grain under optimum temperature conditions.

2. Material and methods

Experimental Design

The research was conducted at Post Graduate Institute Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, District Ahmednagar (MH). The tested crop was two genotypes of wheat with one heat tolerant check and one heat susceptible check *viz*., NIAW-3033, NIAW- 3161, NIAW-1994 (Resistant check) and MACS-6222 (Susceptible check) respectively. The crop was sown at 22.5 cm spacing between two rows and total land used was 4R. Experimental design used was split plot design. Seed material was obtained from Agriculture Research Station, Niphad, District Nashik (MH)

2.2. Method used for estimation of internodes WSC content

Collection of stem samples

Stem samples were collected and cut them at internode points then dried them in hot air oven upto constant weight and grinded it to make it accessible for biochemical analysis of WSC.

Estimation of WSC

Carbohydrates are first hydrolysed into simple sugars using dilute hydrochloric acid. In hot acidic medium glucose is dehydrated to hydroxymethyl furfural. This compound forms with anthrone a green coloured product with an absorption maximum at 630 nm.

Material

1. 2.5 N HCl
2. Anthrone reagent: Dissolve 200 mg anthrone in 100 mL of ice cold 95% H_2SO4. Prepare fresh before use.
3. Standard glucose-: Stock- Dissolve 100 mg in 100 mL of distilled water. Working standard- 10 mL of stock diluted in 100 mL with distilled water. Store refrigerated after adding a few drops of toluene.

Procedure

1. Weigh 100 mg of sample into a glass tube.
2. Hydrolyse by keeping it in a boiling water bath for three hours with 5 mL of 2.5 N-HCl and cool to room temperature.
3. Neutralise it with solid sodium carbonate until the effervescence ceases.
4. Make up the volume 100 ml and centrifuge.

5. Collect the supernantent and take 0.5 and 1 mL aliquots for analysis.
6. Prepare the standards by taking 0, 0.2, 0.4, 0.6, 0.8 and 1of the working standards. '0' serves as blank.
7. Make up the volume to 1 ml and in all the tubes including the sample tubes by adding distilled water.
8. Then add 4 ml of anthrone reagent.
9. Heat for eight minutes in a boiling water bath.
10. Cool rapidly and read the green to dark green colour at 630 nm.
11. Draw a standard graph by plotting concentration of the standard on the X-axis versus absorbance at the Y-axis
12. From the graph calculate the amount of carbohydrate present in sample tube.

Data analysis

All the data were produced using Microsoft Excel 2016 software and statistically analyzed for split plot design with the assistance of Department of Statistics, MPKV, Rahuri.

3. Results and Discussion

Effect of temperature regime on WSC

Elevated temperature stress on stem WSC was found to significantly decreased under controlled environment conditions. As temperature increased synthesis of WSC also get hampered due to stressed photosynthetic activities. It could be concluded that wheat genotypes with higher stem WSC reserves and mobilization might have superior buffering of grain growth, grain filling and development under heat stress conditions.

Apical internode contributed more for stem reserve and maximum WSCs were transported from it. Genotype NIAW-3033 performed best among all the genotypes for internodes WSC content and genotype NIAW-3161 expressed less WSCs in all the internodes. So, for field trial, genotype NIAW-3033 along with check NIAW-1994 (Phule Samadhan) and genotype NIAW-3161 along with susceptible check MACS-6222 were planted in delayed sowing dates with one month difference.

Water soluble carbohydrates were analyzed from different internodes of wheat stem for five weeks from anthesis till physiological maturity. These internodes showed varying concentrations of water soluble carbohydrates and the concentration of WSC found reduced as the grain growth and maturation takes place and plant matures.

1. Internodes WSC content: 1st week after anthesis (mg g^{-1} dry weight)

Significantly higher amount of water soluble carbohydrates were found in genotype NIAW-1994 (Phule Samadhan) *viz.*, basal (253.52), middle (325.63), apical (316.88) and peduncle (332.81) which was followed by NIAW-3033 viz., basal (255.06), middle (265.52), apical (298.74) and peduncle (290.04), whereas NIAW-3161 exhibited least amount of WSC content in basal (208.85), middle (243.47), apical (256.55) and peduncle (254.37). **2. Internodes WSC content: 2nd week after anthesis (mg g^{-1} dry weight)**

During 2nd week of anthesis higher amount of WSC were found in genotype NIAW-1994 (Phule Samadhan) *viz.*, basal (252.02), middle (266.50), apical (333.52) and peduncle (320.19) which was followed by NIAW-3033 *viz.*, basal (231.79), middle (265.95), apical (300.62) and peduncle (300.29).

3. Internodes WSC content: 3rd week after anthesis (mg g^{-1} dry weight)

Mean values of stem WSC were found decreased as sowing date delayed.

Comparatively maximum amount of stem WSC were found in genotype NIAW-1994 (Phule Samadhan) *viz.*, basal (176.23), middle (303.26), apical (286.16) and peduncle (287.19) which was followed by NIAW-3033 *viz.,* basal (168.13), middle (212.26), apical (258.92) and peduncle (276.68), whereas NIAW-3161 exhibited least amount of WSC content in all the internodes.

4. Internodes WSC content: 4th week after anthesis (mg g^{-1} dry weight)

Water soluble carbohydrates were found to be decreasing as sowing delayed. Among all the genotypes under study, significantly higher concentration of stem WSC were found in genotype NIAW-1994 (Phule Samadhan) *viz.*, basal (67.45), middle (93.67), apical (128.28) and peduncle (113.66) which was followed by NIAW-3033 *viz.,* basal (66.06), middle (85.04), apical (118.62) and peduncle (109.06).

5. Internodes WSC content: 5th week after anthesis (mg g^{-1} dry weight)

The concentration of stem WSC was found to be in decreasing order as sowing dates delayed because temperature was found to be increasing. Among the genotypes under study, more amount of water soluble carbohydrates were found in genotype NIAW-1994 (Phule Samadhan) *viz.*, basal (52.18), middle (62.57), apical (78.52) and peduncle (76.82) which was followed by NIAW-3033 *viz.,* basal (49.13), middle (62.80), apical (80.74) and peduncle (76.83).

Irrespective of normal and late sown conditions, there was continuous decline of total carbohydrates in all the genotypes which may be correlated to their rapid utilization for the synthesis of carbohydrate polymer mainly starch. In late sown genotypes there was more decline in total carbohydrates content. Since, temperature was also high during late sown condition, so it is quite likely that higher utilization of sugars prevails during stress conditions. It has also been reported that free sugars decline during biotic or abiotic stresses to overcome stress and sugars are essential to plant growth and metabolism both as energy source and structural components (Rook *et al.,* 2006). An increase in assimilate availability around anthesis is able to improve the distal grain weight (Roder *et al.,* 2008).

Plaut *et al*., (2004) reported that high temperature reduced the rate of transport of dry matter from vegetative organs to kernel, but sensitivity to high temperature stress differed with varieties. Our data indicated variations in days to anthesis for normal and late sown wheat genotypes, which was reflected in their stem WSC synthesis and remobilization towards grains.

All the genotypes expressed significant variation for Water Soluble Carbohydrates. Genotypes NIAW-1994 and NIAW-3033 performed best than rest of the two genotypes in all the internodes namely basal, middle, apical and peduncle. Water soluble carbohydrates were analyzed from different internodes of wheat stem for five weeks from anthesis till physiological maturity. These internodes showed varying concentrations of water soluble carbohydrates and the concentration of WSC found reduced as the grain growth and maturation takes place and plant matures. For three sowing dates, NIAW-1994 (Phule Samadhan) showed significantly maximum concentration of water soluble carbohydrates from different internodes of wheat stem than genotype NIAW-3033. Genotype NIAW-3161 was having relatively less amount of

water soluble carbohydrates from all the internodes than MACS-6222 in all the three sowing dates. This stem reserved WSC are the principal component for grain filling during any environmental stress condition.

4. Conclusions

1. Elevated temperature caused significant yield loss. High temperature stress was found to be occured due to delayed sowing dates. Stem reserves in the form of WSCs efficiently carried grain filling under elevated temperature stress condition.
2. Genotypes under study exhibited variation for stem reserve mobilization under temperature stress condition by expressing grain filling under stress condition. Genotype NIAW-3033 performed best among all the genotypes for having maximum stem reserves and effective remobilization towards grains.
3. Out of all four internodes, apical internode contributes more than rest of the three. Amount of WSC found were maximum in this internode.
4. According to results obtained from field trial it can be concluded that the higher capability of the tall wheat cultivar, NIAW-3033 to tolerate thermal stress is due to its ability of synthesizing and storing larger concentration of WSC in its stems, stronger sink activity and longer duration of grain maturation under temperature conditions, suggesting its use in breeding program or in heat stress prone area where other sensitive wheat cultivars may be severely affected.

5. Acknowledgements

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Table 1: Water Soluble Carbohydrates: 1st week after anthesis (mg g^{-1} dry weight)

	Basal				Middle				Apical				Peduncle			
Genotypes	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**
NIAW-3033	278.66	252.37	234.16	255.06	296.59	263.54	236.42	265.52	367.42	277.56	251.24	298.74	326.16	289.65	254.32	290.04
NIAW-1994	264.55	255.84	240.17	253.52	384.63	315.66	276.59	325.63	412.36	285.62	252.66	316.88	426.56	296.26	275.61	332.81
NIAW-3161	239.57	208.56	178.43	208.85	257.68	251.06	221.67	243.47	306.55	246.57	216.54	256.55	284.22	254.29	224.59	254.37
MACS-6222	255.69	216.44	176.55	216.23	266.84	251.74	223.50	247.36	324.62	254.26	219.67	266.18	311.47	261.27	226.44	266.39
Mean	259.62	233.30	207.33	233.42	301.44	270.50	239.55	270.49	352.74	266.00	235.03	284.59	337.10	275.37	245.24	285.90
	D	**G**	**D×G**		**D**	**G**	**D×G**		**D**	**G**	**D×G**		**D**	**G**	**D×G**	
SE	6.67	3.13	5.42		2.89	4.42	7.65		2.18	4.38	7.59		4.09	5.10	8.83	
CD at 5%	26.19	9.30	16.10		11.34	13.13	22.74		8.58	13.03	22.57		16.06	15.16	26.26	

*SD- Sowing date

Table 2: Water Soluble Carbohydrates: 2nd week after anthesis (mg g^{-1} dry weight)

	Basal				Middle				Apical				Peduncle			
Genotypes	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**
NIAW-3033	252.24	223.47	219.67	231.79	281.63	274.59	241.62	265.95	348.74	309.44	243.67	300.62	321.74	311.54	267.59	300.29
NIAW-1994	294.66	240.32	221.09	252.02	280.64	275.66	243.21	266.50	387.59	326.75	286.21	333.52	311.68	342.15	306.75	320.19
NIAW-3161	231.33	196.25	168.56	198.71	243.52	231.57	224.75	233.28	273.59	226.24	204.09	234.64	314.69	275.64	239.45	276.59
MACS-6222	233.41	205.63	170.55	203.20	274.69	236.52	225.86	245.69	276.88	222.75	211.13	236.92	312.54	286.59	241.63	280.25
Mean	252.91	216.42	194.97	221.43	270.12	254.59	233.86	252.86	321.70	271.30	236.28	276.42	315.16	303.98	263.86	294.33
	D	**G**	**D×G**		**D**	**G**	**D×G**		**D**	**G**	**D×G**		**D**	**G**	**D×G**	
SE	3.31	3.83	6.63		3.06	4.29	7.43		3.50	4.45	7.71		5.49	7.47	12.94	
CD at 5%	12.99	11.38	NS		12.01	12.74	NS		13.75	13.23	22.91		21.59	22.21	NS	

*SD- Sowing date

Table 3: Water Soluble Carbohydrates: 3rd week after anthesis (mg g-1 dry weight)

	Basal				Middle				Apical				Peduncle			
Genotypes	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**
NIAW-3033	186.62	165.70	152.06	168.13	244.71	209.41	182.65	212.26	289.69	255.84	231.24	258.92	316.86	277.86	235.33	276.68
NIAW-1994	205.42	170.43	152.83	176.23	374.26	275.69	259.84	303.26	316.44	286.41	255.62	286.16	341.29	281.53	238.74	287.19
NIAW-3161	146.57	132.44	126.41	135.14	213.64	204.59	171.24	196.49	254.65	239.26	216.67	236.86	275.61	236.95	213.86	242.14
MACS-6222	158.67	140.63	126.88	142.06	219.76	208.45	171.74	199.98	260.87	243.68	223.29	242.61	287.64	243.11	214.29	248.35
Mean	174.32	152.30	139.55	155.39	263.09	224.54	196.37	228.00	280.41	256.30	231.71	256.14	305.35	259.86	225.56	263.59
	D	**G**	**D×G**		**D**	**G**	**D×G**		**D**	**G**	**D×G**		**D**	**G**	**D×G**	
SE	5.69	4.53	7.85		3.90	4.55	7.88		5.92	10.15	17.58		2.48	4.66	8.07	
CD at 5%	22.34	13.46	NS		14.33	13.52	23.42		23.24	30.16	NS		9.73	13.84	NS	

*SD- Sowing date

Table 4: Water Soluble Carbohydrates: 4th week after anthesis (mg g-1 dry weight)

	Basal				Middle				Apical				Peduncle			
Genotypes	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**
NIAW-3033	80.67	68.75	48.77	66.06	96.30	88.98	69.85	85.04	132.67	116.32	106.87	118.62	126.54	112.04	88.59	109.06
NIAW-1994	84.59	68.91	48.86	67.45	106.43	102.71	70.96	93.37	143.26	132.17	109.42	128.28	122.36	115.34	103.27	113.66
NIAW-3161	55.79	46.19	34.29	45.42	74.21	56.30	43.67	58.06	112.64	94.51	71.65	92.93	95.66	81.66	67.51	81.61
MACS-6222	64.53	46.84	35.08	48.82	75.52	61.12	45.21	60.62	123.34	97.64	73.16	98.05	102.34	81.74	67.85	83.98
Mean	71.40	57.67	41.75	56.94	88.12	77.28	57.42	74.27	127.98	110.16	90.28	109.47	111.73	97.70	81.81	97.08
	D	**G**	**D×G**		**D**	**G**	**D×G**		**D**	**G**	**D×G**		**D**	**G**	**D×G**	
SE	1.41	1.09	1.89		1.32	2.22	3.85		1.42	2.92	5.06		1.85	1.99	3.45	
CD at 5%	5.56	3.24	5.62		5.19	6.60	NS		5.57	8.69	NS		7.26	5.93	NS	

*SD- Sowing date

Table 5: Water Soluble Carbohydrates: 5th week after anthesis (mg g^{-1} dry weight)

	Basal				Middle				Apical				Peduncle			
Genotypes	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**	**SD-1**	**SD-2**	**SD-3**	**Mean**
NIAW-3033	68.75	47.57	31.08	49.13	86.32	69.56	32.51	62.80	96.67	84.46	61.09	80.74	102.62	78.45	49.41	76.83
NIAW-1994	70.45	51.97	34.12	52.18	84.58	70.19	32.95	62.57	87.48	84.69	63.40	78.52	98.65	79.55	52.27	76.82
NIAW-3161	59.67	43.74	23.18	42.20	70.19	46.33	26.84	47.79	69.85	53.62	42.61	55.36	76.56	64.21	36.14	58.97
MACS-6222	60.16	46.19	23.56	43.30	70.96	46.74	27.56	48.42	71.49	54.41	43.22	56.37	81.36	63.19	37.75	60.77
Mean	64.76	47.37	27.99	46.70	78.01	58.21	29.97	55.39	81.37	69.30	52.58	67.75	89.80	71.35	43.89	68.35
	D	**G**	**D×G**		**D**	**G**	**D×G**		**D**	**G**	**D×G**		**D**	**G**	**D×G**	
SE	0.76	0.81	1.41		1.09	1.10	1.91		0.71	1.11	1.91		1.07	1.54	2.66	
CD at 5%	3.01	2.42	NS		4.28	3.27	5.67		2.80	3.28	5.69		4.21	4.88	NS	

*SD- Sowing date

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