Reprint ISSN 1923-7766 (Web Version)

International Journal of Experimental Agriculture

(Int. J. Expt. Agric.)

Volume: 13	Issue: 1	January 2023

Int. J. Expt. Agric. 13(1): 8-12 (January 2023)

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An International Scientific Research Publisher

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ISSN-1923-7766 (Online)
Int. J. Expt. Agric. 13(1):8-12(January 2023)

EFFECT OF HIGH TEMPERATURE AT REPRODUCTIVE PHASE OF AMAN RICE VARIETIES

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Accepted for publication on 05 December 2022

ABSTRACT

Islam MT, Akter SE (2023) Effect of high temperature at reproductive phase of aman rice varieties. *Int. J. Expt. Agric*. 13(1), 8-12.

Temperature is one of the most important environmental factors influencing crop growth, development and yield processes. Temperature is becoming the major concern for plant scientists worldwide due to the changing climate. Four Aman rice varieties (Binadhan-16, Binadhan-17, Binadhan-22 and Binadhan-23) were evaluated under high temperature (36^{o}C) at booting, flowering and grain filling stages for 5 days along with ambient temperature. Nitrate reductase activity was the lowest with high temperature at grain filling stage followed by flowering and booting stage. Total chlorophyll content was the lowest with high temperature at flowering stage followed by grain filling and booting stage. Among the varieties, Binadhan-16 had the highest nitrate reductase activity and Binadhan-23 showed the highest chlorophyll content. Plant height was decreased more with high temperature at booting stage followed by grain filling stage. Number of effective tillers and total tillers hill^{-1} was not significantly affected by the temperature treatments. Reduced panicle length was found only with high temperature at booting stage. The lowest number of grains hill^{-1} was found with high temperature at booting stage followed by flowering and grain filling stage. The highest number of unfilled grains hill^{-1} was observed with high temperature at flowering stage followed by booting and grain filling stage. Thousand grains weight was significantly reduced but straw weight increased with high temperature at all the growth stages. Yield hill^{-1} was significantly decreased with high temperature at flowering stage followed by booting and grain filling stage. Among the varieties Binadhan-23 showed the highest values of chlorophyll content, nitrate reductase activity, yield and yield attributes followed by Binadhan-17.

Key words: *high temperature, aman rice, booting, flowering, grain filling, yield*

INTRODUCTION

Temperature is one of the most important environmental factors influencing crop growth, development, and yield processes. Temperature is becoming the major concern for plant scientists worldwide due to the changing climate. Global climate change is making high temperature a critical factor for plant growth and productivity. It is now considered to be one of the major abiotic stresses for restricting crop production, which has a favorable and in some cases unfavorable influence on the development, growth and yield of rice. Rice being a tropical and sub-tropical plant requires a fairly high temperature, ranging from 20°C to 40°C. Rice cultivation is conditioned by temperature parameters at the different phases of growth. Climate model predicts 33%rice yield decrease in 2100 (Karim *et al*. 2012). Grain filling is the final stage of growth in cereals where fertilized ovaries develop into caryopses. Grain filling in cereals depends on carbon from two sources: current assimilates transferred directly to the grain and assimilates redistributed from reserve pools in vegetative tissues either prior post-anthesis (Schnyder 1993). Rice grain dry weight increased from fertilization to 18-24 days (Moonmoon *et al*. 2020a; Hafiz *et al*. 2015; Islam 2010; Islam *et al*. 2005b; Islam and Gretzmacher, 2001). The yield of rice is an integrated result of various processes including canopy photosynthesis, conversion of assimilates to biomass, and partitioning of assimilates to grains (Jeng *et al*. 2006). High temperature and drought stress affects growth and yield of rice (Islam 2021; Islam and Khatoon, 2019; Moonmoon *et al*. 2017; Islam *et al*. 2012; Islam *et al*. 2005c; Islam 2001). In Bangladesh, Boro rice often suffers with high temperature during its reproductive stages in April-May and Aman rice occasionally in September-October. Aman rice is rain fed cultivated during June-December. It passes through vegetative stage during August to September when rainfall is usually sufficient. The crop suffers from moisture stress when the rainfall usually ceases by the first week of October in Bangladesh. By this time, it passes through reproductive. The total rainfall in these two months is very irregular and often inadequate which fails to meet the evapotranspirational demand of Aman rice consequently develops water stress and affects translocation of assimilates and grain development in rice (Moonmoon *et al*. 2020c; Rahman *et al*. 2002). Drought stress affects plant growth and development, and ultimately reduces grain yield of rice (Moonmoon *et al*. 2020b; Moonmoon and Islam, 2017; Zohora *et al*. 2016; Islam *et al*. 2005a; Islam *et al*. 1994a; Islam *et al*. 1994b). The response of rice yield to drought varies with growth stage being most sensitive at booting followed by flowering and or grain filling stage (Islam *et al*. 1994a). The early reproductive growth period, encompassing tetrad-formation stage of miosis (i.e., about 10-15 d prior to heading), was found to be the most sensitive and critical to water deficit resulting in up to 59% grain sterility that caused similar magnitude of yield reduction. As the grain formation progressed further, the early period of grain-filling was found to be more vulnerable to water stress than the late-milk stages (Singh *et al*. 2010). Rice yield significantly decreased with high temperature (36^{o}C) at different growth stages (Islam 2022b). With all those factors above in mind, this study was carried out to assess the effect of high temperature at booting, flowering and grain filling stage of rice genotypes.

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The experiment was conducted at the pot yard and plant growth chamber of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh. The soils of the experiment were collected from the field of BINA Farm. The collected soil was pulverized, inert materials, visible insect pest and plant propagules were removed. Pots were filled with top soils. The pot was 25 cm deep with 27 cm diameter at the top. The pots were placed at the pot yard of Crop Physiology Division, BINA, Mymensingh. Each pot contained 12 kg soil. All soils pots were fertilized with urea, TSP, MP and gypsum @ 3.08, 0.70, 1.12 and 0.707 g pot^{-1}, respectively. All TSP, MP, Gypsum and one-third of the urea were applied as basal dose. The remaining two-thirds of the urea were applied in two equal splits in each pot at 25 and 45 days after transplanting. One seedling was transplanted in a puddle pot. For gap filling there were extra seedlings preserved. All necessary intercultural operations, mainly weeding, and irrigation was done as and when necessary. The pot experiment was conducted with three six rice varieties *viz*. Binadhan-16, Binadhan-17, Binadhan-22 and Binadhan-23. The experiment was set in a two factorial RCBD with three replications in during Aman season 2022. The first factor was rice genotypes and the second factor was temperature: ambient, 36°C at booting, and 36°C at flowering stage of the rice varieties. Then all the plants were allowed to continue maturity. Data on yield and yield attributes were recorded at maturity. Data were analyzed statistically and DMRT was adjusted to compare the means.

RESULTS AND DISCUSSION

The results revealed that chlorophyll a, chlorophyll b, total chlorophyll contents and nitrate reductase activity in leaves were the highest in control (Table 1). Nitrate reductase activity was the lowest with high temperature at grain filling stage followed by flowering and booting stage. On the other hand total chlorophyll content was the lowest with high temperature at flowering stage followed by grain filling and booting stage. Among the varieties, Binadhan-16 had the highest nitrate reductase activity and Binadhan-23 showed the highest chlorophyll (Table 2). All the rice varieties significantly reduced nitrate reductase activity and chlorophyll content under high temperature and Binadhan-23 had comparatively less reduction of those (Table 3). Plant height was decreased more with high temperature at booting stage followed by grain filling stage (Table 4). Number of effective tillers and total tillers hill^{-1} was not significantly affected by the temperature treatments. Reduced panicle length was found only with high temperature at booting stage. The lowest number of grains hill^{-1} was found with high temperature at booting stage followed by flowering and grain filling stage. On the other hand the highest number of unfilled grains hill^{-1} was observed with high temperature at flowering stage followed by booting and grain filling stage. Thousand grains weight was significantly reduced but straw weight increased with high temperature at all the growth stages. Yield hill^{-1} was significantly decreased with high temperature at flowering stage followed by booting and grain filling stage. Among the varieties Binadhan-23 showed the highest grain weight hill^{-1} followed by Binadhan-17 under the temperature treatments (Table 5). Yield hill^{-1} was significantly reduced by high temperature in all the varieties however Binadhan-23 had less reduction (Table 6). The results are in conformity with many authors (Islam 2022a; Islam and Arefin 2022; Islam 2021; Saha *et al*. 2020; Haque *et al*. 2020; Hazra *et al*. 2016; Islam 2013).

Table. 1. Main effect of temperature on chlorophyll content and nitrate reductase activity of rice varieties leaves

Treatment	NRA (μmolNO$_2$ g^{-1} fwh^{-1})	Chlorophyll a (mgg^{-1}fw)	Chlorophyll b (mgg^{-1}fw)	Total chlorophyll (mgg^{-1}fw)
T_1	0.79a	18.02a	8.73a	26.75a
T_2	0.66b	16.62b	6.85b	23.47b
T_3	0.55c	11.50c	4.01d	15.50d
T_4	0.48d	12.06c	5.88c	17.94c
CV (%)	3.21	5.99	7.28	5.11

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT. Where T_1: Ambient temperature, T_2: High temperature (36°C) at booting stage, T_3: High temperature (36°C) at flowering stage and T_4: High temperature (36°C) at grain filling stage.

Table 2. Main effect of varieties on chlorophyll content and nitrate reductase activity under high temperature

Variety	NRA (μmolNO$_2$ g^{-1} fwh^{-1})	Chlorophyll a (mgg^{-1}fw)	Chlorophyll b (mgg^{-1}fw)	Total chlorophyll content (mgg^{-1}fw)
V_1	0.67b	15.48a	8.20a	23.68a
V_2	0.62c	14.02b	6.46b	20.48b
V_3	0.49d	13.56b	4.72d	18.29c
V_4	0.69a	15.13a	6.08c	21.21b
CV (%)	3.21	5.99	7.28	5.11

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT. Where V_1: Binadhan-16, V_2: Binadhan-17, V_3: Binadhan-22 and V_4: Binadhan-23.

Table 3. Combined effect of temperature and rice variety on chlorophyll content and nitrate reductase activity in leaves

Interaction	NRA ($\mu molNO_2\ g^{-1}fwh^{-1}$)	Chlorophyll a ($mgg^{-1}fw$)	Chlorophyll b ($mgg^{-1}fw$)	Total chlorophyll content ($mgg^{-1}fw$)
$V_1 \times T_1$	0.85b	19.82ab	11.51a	31.33a
$V_1 \times T_2$	0.58f	18.43b	8.65d	27.07c
$V_1 \times T_3$	0.78d	10.38fg	2.31l	12.69j
$V_1 \times T_4$	0.48h	13.29e	10.33b	23.62de
$V_2 \times T_1$	0.79cd	20.46a	9.75bc	30.22ab
$V_2 \times T_2$	0.73e	19.44ab	9.03cd	28.47bc
$V_2 \times T_3$	0.46h	9.75g	4.13ij	13.88j
$V_2 \times T_4$	0.52g	6.42h	2.95kl	9.37k
$V_3 \times T_1$	0.60f	15.05d	5.86g	20.91fg
$V_3 \times T_2$	0.51g	14.52de	5.19gh	19.71gh
$V_3 \times T_3$	0.40i	11.49f	4.33i	15.82i
$V_3 \times T_4$	0.46h	13.20e	3.50jk	16.70i
$V_4 \times T_1$	0.92a	16.75c	7.77e	24.52d
$V_4 \times T_2$	0.81c	14.09de	4.56hi	18.64h
$V_4 \times T_3$	0.57f	14.36de	5.25gh	19.62gh
$V_4 \times T_4$	0.46h	15.33cd	6.72f	22.05ef
CV (%)	3.21	5.99	7.28	5.11

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT. Where V_1: Binadhan-16, V_2: Binadhan-17, V_3: Binadhan-22 and V_4: Binadhan-23, T_1: Ambient temperature, T_2: High temperature (36^{o}C) at booting stage, T_3: High temperature (36^{o}C) at flowering stage and T_4: High temperature (36^{o}C) at grain filling stage.

Table 4. Main effect of temperature on morphological attributes and yield of rice varieties

Treatment	Plant height (cm)	Effective tiller $hill^{-1}$ (no.)	Total tiller $hill^{-1}$ (no.)	Panicle length (cm)	Grain $panicle^{-1}$ (no.)	Unfilled grain $panicle^{-1}$ (no.)	1000-grain weight(g)	Straw weight $hill^{-1}$ (g)	Grain weight $hill^{-1}$ (g)
T_1	101.92a	18.83a	19.75a	27.01a	149.41a	49.94d	21.45a	37.47b	32.90a
T_2	91.42c	17.25a	19.83a	25.43b	42.81c	136.07b	19.91b	56.33a	3.68c
T_3	98.08b	17.50a	19.58a	27.10a	23.16d	200.89a	19.30c	61.25a	3.05d
T_4	102.58a	19.75a	22.17a	27.22a	54.68b	134.84c	19.57bc	57.18a	6.54b
CV (%)	4.19	15.70	17.99	5.89	0.52	0.47	6.34	16.63	3.31

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT. Where T_1: Ambient temperature, T_2: High temperature (36^{o}C) at booting stage, T_3: High temperature (36^{o}C) at flowering stage and T_4: High temperature (36^{o}C) at grain filling stage.

Table 5. Main effect of varieties on morphological attributes and yield under high temperature

Variety	Plant height (cm)	Effective tiller $hill^{-1}$ (no.)	Total tiller $hill^{-1}$ (no.)	Panicle length (cm)	Grain $panicle^{-1}$ (no.)	Unfilled grain $panicle^{-1}$ (no.)	1000-grain weight (g)	Straw weight $hill^{-1}$ (g)	Grain weight $hill^{-1}$ (g)
V_1	96.00b	18.33ab	20.58a	25.87b	63.94c	105.30d	23.21a	48.60b	11.85b
V_2	96.25b	18.92ab	21.00a	25.17b	61.10d	147.91b	17.28c	56.42a	11.36b
V_3	94.83b	16.58b	17.83b	27.73a	67.92b	154.76a	19.87b	45.73b	9.60c
V_4	106.92a	19.50a	21.92a	27.99a	77.10a	113.78c	19.87b	61.48a	13.36a
CV (%)	4.19	15.70	17.99	5.89	0.52	0.47	6.34	16.63	3.31

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT. Where V_1: Binadhan-16, V_2: Binadhan-17, V_3: Binadhan-22 and V_4: Binadhan-23.

Table 6. Combined effect of temperature and rice variety on morphological attributes and yield

Interaction	Plant height (cm)	Effective tiller hill^{-1} (no.)	Total tiller hill^{-1} (no.)	Panicle length (cm)	Grain panicle^{-1} (no.)	Unfilled grain panicle^{-1} (no.)	1000-grain weight (g)	Straw weight hill^{-1} (g)	Grain weight hill^{-1} (g)
$V_1 \times T_1$	100.67bc	17.00abc	18.00def	26.80a-e	143.74c	37.21n	24.83a	29.27d	34.97b
$V_1 \times T_2$	91.67de	17.00abc	19.33c-f	25.03de	35.55l	102.79k	23.70b	47.83bc	3.19hi
$V_1 \times T_3$	95.00cde	21.67ab	25.00ab	26.27b-e	3.11n	174.08c	20.25de	69.90a	2.59hi
$V_1 \times T_4$	96.67cd	17.67abc	20.00b-f	25.37cde	73.38d	107.10j	24.08ab	47.40bc	6.66e
$V_2 \times T_1$	100.67bc	21.33ab	22.33a-e	24.27e	150.46b	72.84l	18.90f	43.23cd	33.37c
$V_2 \times T_2$	89.00ef	17.00abc	19.67c-f	24.43de	48.58g	123.58h	16.94gh	57.97ab	2.56hi
$V_2 \times T_3$	94.67cde	15.00c	16.67f	25.67cde	7.47m	233.65b	17.32g	56.20abc	2.12i
$V_2 \times T_4$	100.67bc	22.33a	25.33a	26.30b-e	37.88j	161.57e	15.98h	68.27a	7.38e
$V_3 \times T_1$	97.67cd	14.67c	15.33f	29.00a	153.52a	65.58m	21.48c	30.43d	24.77d
$V_3 \times T_2$	83.67f	17.00abc	18.00def	25.27de	36.36k	153.38g	19.17ef	50.63bc	3.67gh
$V_3 \times T_3$	97.00cd	16.67bc	17.67ef	27.93abc	42.33h	242.50a	19.80def	50.00bc	4.58fg
$V_3 \times T_4$	101.00bc	18.00abc	20.33a-f	28.73ab	39.48i	157.58f	19.03f	51.83bc	5.40f
$V_4 \times T_1$	108.67a	22.33a	23.33abc	27.97abc	149.91b	24.14o	20.60cd	46.93bc	38.50a
$V_4 \times T_2$	101.33bc	18.00abc	22.33a-e	27.00a-d	50.76f	164.55d	19.84def	68.90a	5.28f
$V_4 \times T_3$	105.67ab	16.67bc	19.00c-f	28.53ab	39.73i	153.32g	19.84def	68.90a	2.93hi
$V_4 \times T_4$	112.00a	21.00ab	23.00a-d	28.47ab	68.00e	113.11i	19.21ef	61.20ab	6.74e
CV (%)	4.19	15.70	17.99	5.89	0.52	0.47	6.34	16.63	3.31

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT. Where V_1: Binadhan-16, V_2: Binadhan-17, V_3: Binadhan-22 and V_4: Binadhan-23. T_1: Ambient temperature, T_2: High temperature (36^{o}C) at booting stage, T_3: High temperature (36^{o}C) at flowering stage and T_4: High temperature (36^{o}C) at grain filling stage.

CONCLUSION

Chlorophyll content, nitrogen reductase activity in leaves, yield and yield attributes of the rice varieties were significantly decreased with high temperature at booting, flowering and grain filling stage. However, high temperature at flowering stage was found more detrimental for grain yield. Binadhan-23 showed higher values in most of the characters.

REFERENCES

Hafiz MA, Islam MT, Karim MA (2015) Grain growth and yield performance of aromatic rice genotypes underdifferent soil moisture regimes. *Int. J. Sustain. Crop Prod*. 10(2), 44-47.

Haque MS, Saha NR, Islam MT, Islam MM, Kwon SJ, Roy SK, Woo SH (2020) Screening for drought tolerance in wheat genotypes by morphological and SSR markers. *J. Crop Sci. Biotechnol*. Springer publication. https://doi.org/10.1007/s12892-020-00036-7

Hazra P, Islam MT, Das GC (2016) Effect of high temperature on some physiological parameters of grain growth and yield of boro rice varieties. *J. Biosci. Agric. Res*. 7(1), 600-607.

Islam MT (2001) Screening of some transplanted aman rice cultivars under water stress condition. *Bangladesh J. Train. Devt*. 14(1&2), 213-220.

Islam MT (2010) Photosynthesis, conductance, transpiration, water use efficiency and grain growth of high yielding rice varieties under water stress. *Int. J. Expt. Agric*. 1(2), 1-4.

Islam MT (2013) Photosynthesis, chlorophyll stability and grain growth of aromatic rice genotypes under hightemperature stress. *Bangladesh J. Nuclear Agric*. 27 & 28, 9-14.

Islam MT (2021) High soil moisture at flowering stage of boro rice varieties reduces high temperature effect. *Int. J. Sustain. Crop Prod*. 11(2), 11-14.

Islam MT (2022a) Effect of high temperature on photosynthesis, stomatal conductance, transpiration, and yield of boro rice varieties under different soil moisture regimes. *Bangladesh J. Nuclear Agric*. 36(1), 65-72.

Islam MT (2022b) Effect of high temperature at different growth stages of short duration aman rice varieties. *Int. J. Sustain. Crop Prod*. 17(2), 16-19.

Islam MT, Arefin KS (2022) Photosynthesis, chlorophyll flouroscence, stomatal conductance, transpiration, water use efficiency and yield of aman rice genotypes under high temperature at different growth stages. *Int. J. Sustain. Crop Prod*. 17(1), 22-26.

Islam MT, Gretzmacher R (2001) Grain growth pattern and yield performance of some transplanted aman rice cultivars in relation to moisture stress. *Bangladesh J. Nuclear Agric*. 16&17, 21-28.

Islam MT, Hossain MA, Islam MT (2005a) Effect of soil moisture on morpho-physiological and yield attributes of boro rice genotypes. J. *Bangladesh Soc. Agric. Sci. Technol*. 2 (3&4), 81-84.

Islam MT, Islam MN, Hossain MA, Karim MA (2012) Effects of water stress on morpho-physiological characters and yield of rice genotypes. *Int. J. Sustain. Crop Prod*. 7(1), 6-11.

Islam MT, Islam MT, Salam MA (1994b) Growth and yield performance of some rice genotypes under different soil moisture regimes. *Bangladesh J. Train. Devt*. 7(2), 57-62.

Islam MT, Khan MEH, Islam MT (2005b) Grain growth pattern and yield attributes of boro rice genotypes under soil moisture stress. *J. Bangladesh Soc. Agric. Sci. Technol*. 2(3&4), 25-28.

Islam MT, Khatoon M (2019) Effect of different temperature levels on germination, root and shoot developmentof rice varieties. *Int. J. Expt. Agric*. 9(2), 11-12.

Islam MT, Salam MA, Kauser M (1994a) Effect of water stress at different growth stages of rice on yield components and yield. *Progress. Agric*. 5(2), 151-156.

Islam Z, Islam MT, Islam MO (2005c) Effect of soil moisture on dry matter production and yield of boro riceunder pot culture conditions. *Bangladesh J. Crop Sci*. 16(1), 37-43.

Jeng TL, Tseng TH, Wang CS, Chen CL, Sung JM (2006) Yield and grain uniformity in contrasting rice genotypes suitable for different growth environments. *Field Crops Res*. 99, 59-66.

Karim MR, Ishikawa M, Ikeda M, Islam MT (2012) Climate change model predicts 33% rice yield decrease in2100 in Bangladesh. *Agron. Sustain. Dev*., DOI 10.1007/s13593-012-0096-7

Moonmoon S, Fakir MSA, Islam MT (2017) Effect of drought stress on grain dry weight, photosynthesis and chlorophyll in six rice genotypes. *Sch J Agric Vet Sci*. 4(1), 13-17.

Moonmoon S, Fakir MSA, Islam MT (2020a) Assimilation of grain on yield and yield attributes of rice (*Oryza sativa* L.) genotypes under drought stress. *Fourrages*. 241(3), 85-98.

Moonmoon S, Fakir MSA, Islam MT (2020b) Effect of drought on morphology and dry matter partitioning at panicle stage in rice genotypes. *Fourrages*. 242(6), 19-30.

Moonmoon S, Fakir MSA, Islam MT (2020c) Modulation of morpho-physiology in rice at early tillering stage under drought stress. Role of photosynthates. *Fourrages*. 242(4), 19-37.

Moonmoon S, Islam MT (2017) Effect of drought stress at different growth stages on yield and yield components of six rice (*Oryza sativa* L.) genotypes. *Fundam Appl Agric*., 2(3), 285-289.

Rahman MT, Islam MT, Islam MO (2002) Effect of water stress at different growth stages on yield and yield contributing characters of transplanted aman rice. *Pakistan J. Biol. Sci*. 5(2), 169-172.

Saha NR, Islam MT, Islam MM, Haque MS (2020) Morpho-molecular screening of wheat genotypes for heat tolerance. *African J. Biotechnol*. 19(2), 71-83.

Schnyder H (1993) The role of carbohydrate storage and redistribution in the source-sink relations of wheat and barley during grain filling-a review. *New Phytologist*. 123: 233-245.

Singh S, Singh TN, Chauhan JS (2010) Productivity of hybrid rice. 1. Vernubility to water stress of reproductive development and inhibition of RuBisCO enzyme in upper leaves as major constraints to yield. *J. New Seeds*. 11(4), 328-355.

Zohora FT, Islam MT, Baten MA (2016) Drought tolerance of NERICA rice mutants. *Int. J. Sustain. Crop Prod*. 11(1), 4-8.