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Effect of Temperature Stress on Yield and Quality of Winged Bean

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ABSTRACT: *Winged bean has assumed considerable importance as a protein rich multipurpose legume. The seeds of the plant are richer in some amino acids than other bean seeds. Winged bean plant is moderately tolerant to high temperature and requires a well distributed mean annual rainfall of 150 cm to 200 cm or more. Agriculturists believe that utilization of winged bean should continue to increase in order to provide better nourishment for people throughout the world. For this goal to achieve present production areas must produce more winged bean and new production areas must be established.*

Environmental conditions prior to reproductive development usually affect by influencing photosynthesis per unit of leaf area, canopy development and interception of solar radiation etc. Yield of crop plants reduces significantly with the increase of temperature.

Key Words: *Canopy, temperature, winged bean, yield*

Introduction: The problem of climate change and its possible consequences on agricultural production has received much attention. The obvious result of rising global temperatures will be heat stress on plants that could alter agriculture with respect to types of crops grown. Agricultural scientists should make necessary steps to adopt environment- specific approaches to crop environment. Plant breeding programes need to make necessary changes to adopt environment-specific approaches to crop improvement (Reynolds et al., 2001). Human activities such as burning of fossil fuel, deforestation are responsible for rapid increase of green house gases (Kaufmann and Stern, 1977; Houghton et al., 2001; Stott et al., 2001).m

Future increase in green house gases are projected to raise earth's surface temperature to anywhere between 1.5 to 11°C by 2100 (Stainforth et al., 2005) that would severely reduce crop production. Interactive effects of temperature and CO_2 on different legumes (Ahmed et al., 1993; Prasad et al., 2002, 2003) showed that the positive interaction observed between CO2 and temperature on vegetative growth.

Winged bean (*Phophocarpus tetrogonolobus* L. DC.) also known as Goa bean or four angled bean has been introduced from Mexico in tropical and sub tropical areas in India. This multipurpose legume crop is a valuable source of protein, carbohydrate and minerals (Chandel et al :1979). Nutritionally, the seeds closely resemble with soybean and have the advantage that those possess a pleasant, sweet flavor in contrast to the bitter beany flavour of soybean (Creny et al, 1979.). Winged bean can be profitably used as a source of edible oil. The

exceptional ability of this legume to fix atmospheric NO_2 should not be overlooked. Winged bean plant is moderately tolerant to high temperature and requires a well distributed mean annual rainfall of 150-250 cm or more.

Materials and Methods:

The present study comprised of three accessions of the experimental plant material *Psophocarpus tetragonolobus* (L) DC which were procured from the Regional Station of National Bureau of Plant Genetic Resources (NBPGR) at Akola (Maharashtra, India). The accessions were EC38154, IC95226 and EC38825. Healthy seeds of three accessions were sown at the experimental field, as well as glass houses with specific temperature regulation .Temperatures were maintained though out the growing period of the experimental plant. Effects of three temperatures like high (48^oc), medium (38^oc) and low (20^oc) were applied and the consequent effects over the plant were studied. Important yield attributes e.g. no of fruits/ plant at 50% flowering stage, no of fruits /plant at pre harvesting period wt of 100 grains (g), seed wt /plant(g) etc were studied during experimentation and all the data were recorded properly.

Biochemical estimation of the mature seeds were carried out after proper cleaning. Estimation of protein fraction was done following Lowry et al (1949).Extraction was carried out using the phosphate-buffer (pH 6.8)and its absorption reading in form of optical density (OD value) was measured at 600 nm. The methods consisted of extraction of albumin, globulin, and prolamine with water. 5% Nacl and 60% ethanol respectively before extraction of glutelin with 0.05 (N) NaOH, and measured by folin phenol reagent.

500 mg dry powdered material was taken in a mortar and made paste with 10 ml distilled water. It was kept overnight and then centrifuged at 5000rpm. The supernatant of the solution was collected for albumins fraction and the residues was kept overnight after adding 10 ml of 5% Nacl for globulin fraction.

For Albumin fraction 0.2 ml of the above solution was collected and to it 0.8 ml of distilled water was added. 5 ml of mixture (5:1)of Na_2Co_3 and Rochelle salt and 0.2 ml of diluted folin phenol reagent were added. After 15 minutes the reaction mixture become blue. Estimation of colour intensity was measured by Colorimeter using green filter.

For globulin the residue containing 5% Nacl was centrifuged after 24 hrs. Supernatant was taken and to it 10ml 90% ethanol was added and kept for overnight for prolamine estimation.

The residue containing 60% ethanol was centrifuged after 24hrs and the supernatant was kept for prolamine fraction .After removal of prolamine the residue in the centrifuge tube was taken out for Glutelin estimation.

Estimation of soluble and insoluble carbohydrate was carried out following Mc Cready et al (1950). Extraction of RNA was done following Chowdhury and Chatterjee 1970.

Dried mature seeds were powdered and taken in a beaker. Digestion was carried out with nitric acid and perchloric acid. Standard curve was prepared. The estimation was carried out with the help of Atomic Absorption Spectrophotometer.

Results: The present study shows variation of yield and biochemical components of three cultivars of winged bean (EC38154, IC95226, EC38825) at different environmental conditions. Table1 exhibits effect of temperature on important yield attributes e.g. number of fruits per plant at 50% flowering stage, fruits per plant at pre harvesting period, weight of 100 grains (g), and seed weight per plant (g) of three winged bean cultivars. Table 2 shows effect of temperature on different biochemical parameters of winged bean seed e.g. nitrogen (%), soluble and insoluble carbohydrates (mg/g), protein fractions (%), and nucleic acids (mg/g). Effect of temperature on nutritional quality i. e. important macro nutrient components of winged bean seeds has been revealed in Table 3.

Table1: Effect of temperature on important yield attributes of Winged Bean cultivars

Yield Parameter	Temperature	EC38154	IC 95226	EC 38825
No of fruits/ plant at 50% flowering stage	48^{o} C	30±0.33	26±0.86	19±1.22
	38^{o}C	35 ±0.11	29± 0.98	25± 0.65
	20^{o}C	12± 0.15	20± 0.05	11±0.47
Fruits / plant at Pre harvesting period	48^{o}C`	189± 0.35	150± 0.33	68 ±0.22
	38^{o}C	243± 0.46	202± 0.11	90± 1.05
	20^{o} C	105± 0.75	99 ±0.01	54± 1.09
Weight of 100 grains (gm)	48^{o}C	29.43± 0.42	37.06 ±0.01	30.44± 036
	38^{o}C	30.40 ±0.19	38.85± 0.99	31.60± 0.71
	20^{o}C	31.48± 0.46	38.40± 0.85	29.89 ±0.39
Seed Weight / plant (gm)	48^{o}C	699.34 ±0.31	784.96± 0.27	320.14± 0.26
	38^{o}C	738.72 ±0.28	803.41± 0.15	427.32 ±0.42
	20^{o}C	580.14 ±0.17	595.26 ±0.13	209.15 ±0.68

n=3 ± S.E.

Table 2: Effect of temperature on different biochemical parameters of Winged Bean

Biochemical parameter	Temperature	EC 38154	IC95226	EC 38825
Nitrogen (1%)	48°C	5.59± 0.77	6.99± 0.97	7.95 ±1.23
	38°C	7.14 ±0.98	7.32± 0.82	8.04±0.77
	20°C	4.31± 1.27	5.28 ±0.22	5.25± 0.38
Carbohydrate Soluble (mg/g)	48°C	17.06±0.12	20.76 ±0.45	25.21 ±0.59
	38°C	18.12 ±1.36	24.29 ±0.34	26.35± 0.08
	20°C	10.61 ±0.88	17.85 ±0.01	20.41± 0.34
Carbohydrate Insoluble (mg/g)	48°C	123.18 ±0.72	127.04± 0.27	126.89± 0.42
	38°C	125.75± 0.19	130.28 ±0.12	128.19 ±0.06
	20°C	119.17 ±0.30	120.14± 0.33	120.41 ±0.44
Protein fraction Albumin (%)	48°C	22.30 ±0.04	12.60 ±1.28	18.35± 1.01
	38°C	23.27± 0.56	13.49 ±0.53	20.50 ±0.99
	20°C	20.12 ±0.31	10.23 ±0.01	12.64 ±0.54
Protein fraction Globulin (%)	48°C	70.66 ±0.52	82.96± 0.33	70.33± 1.40
	38°C	72.50± 0.05	84.21 ±0.23	76.60±0.46
	20°C	67.19± 0.49	80.19± 0.52	67.59 ± 0.22
Protein fraction Prolamin (%)	48°C	3.06± 0.46	1.70 ±0.11	1.99± 0.27
	38°C	3.92 0.55	1.82 0.20	2.68 0.39
	20°C	1.83± 0.04	1.37± 0.57	1.59± 0.93
Protein fraction Glitelin (%)	48°C	0.15± 0.46	0.12 ±0.01	0.29± 0.02
	38°C	0.22± 0.02	0.28±0.42	0.45 ±0.01
	20°C	0.05± 1.03	0.03 ±0.27	0.12 ±0.07
DNA (mg/g) fresh weight	48°C	1.72± 0.77	2.00± 0.18	1.67 ±0.09
	38°C	1.82± 0.61	2.23 ±0.18	1.67 ±0.09
	20°C	1.80± 0.58	2.20± 0.48	1.60 ±1.20
RNA (mg/g) fresh weight	48°C	7.44 ±0.05	8.15± 0.56	7.58 ±1.04
	38°C	7.50± 1.43	8.17 ±0.69	7.92± 0.84
	20°C	7.48± 0.86	8.16 ±0.46	7.77 ±0.76

n=3± S.E.

Table 3: effect of temperature on nutritional quality of seed

Nutrient	Temperature	EC38154	IC 95226	EC 38825
Fe (ppm)	48°C	142.10± 1.02	220.05 ±0.33	108.19± 1.03
	38°C	146.95 ±0.02	224.43± 0.55	116.28 ±0.34
	20°C	145.29 ±0.08	221.14± 1.50	112.13 ±0.12
Zn (ppm)	48°C	36.04± 0.22	29.56± 0.28	34.19 ±0.11
	38°C	37.24± 0.19	32.29 ±0.53	35.96 ±0.44
	20°C	35.09± 0.66	30.24± 0.47	30.24± 1.02
Ca (ppm)	48°C	1983.14± 0.54	1648.32± 0.05	1940.34± 0.02
	38°C	2140.28± 0.88	1657.55 ±0.35	1956.16 ±0.01
	20°C	2038.14 ±0.56	1559.12± 0.12	1949.06± 0.25
Mg (ppm)	48°C	325.11± 1.03	344.19± 0.13	330.48 ±0.77
	38°C	331.99± 0.76	344.83± 0.49	339.63 ±0.52
	20°C	320.48± 0.42	340.12 ±0.06	335.16± 1.07

n=3 ± S.E.

Discussion:

Investigations on the effect of different temperatures on different yield attributes revealed that under moderate temperature (38°c) yield was high but yield declined sharply at high and low temperatures. Inhibition of linear growth, Chlorophyll synthesis as well as net assimilatory rate was observed in case of wheat cultivars (Ray et al 1978), which corroborated the winged bean observations. The indirect effect of high temperature injury could be attributed to the decreased level of protein, carbohydrate and lipid biosynthesis. (Levitt, 1972). Investigations on the affect of high (48°c) , moderate (38°c) and low temperature (20°c) on different biochemical components of seed (Protein, soluble and insoluble carbohydrates, Nitrogen DNA, and RNA)revealed that high temperature caused decline of protein content and similarly but deteriorative at low temperature (20°c) where bio synthesis of proteins was more or less inhibited.

The effect of extreme high (48°c) and low (20°c) temperatures on carbohydrate synthesis is exhibited in table2. The effect of heat injury on carbohydrate synthesis was also reported in several plants (Levitt, 1972). Seemingly, changes in nitrogen level were reflected in the protein level changes.

The suppression of nucleic acid biosynthesis revealed under high temperature. The optimum temperature was 38°c. In the low temperature (20°c) yield of DNA and RNA was low. Nucleic acids

level (DNA and RNA) were decreased under low (20^{o}c) and high (48^{o}c) temperatures in comparison to the optimum temperature (38^{o}c) condition.

Different temperature treatments influenced different morpho -physiological characters of winged bean. It was observed that under low temperature (20°C) the number of pod per plant reduced to a maximum extent; while at optimum temperature (38°C) the number of pod increased considerably in all three varieties. In case of EC38154 cultivar the number of fruits per plant at 50% flowering stage was 35 at 38°C, whereas that are 29 and 25 in case of IC95226 and EC38825 respectively. Fruits per plant at pre harvesting period was highest (243) in case of EC38154, and lowest (90) in case of EC38825 38°C. Ten degree centigrade rise of temperature showed a profound effect on those parameters i.e. resulting in decrease in the number of fruits. Seed weight per plant (g) and weight of 100 grains (g) varied considerably with decrease and increase of temperature condition. Seed weight per plant (g) at 38°C in three cultivars were 738.729g, 803.419g and 427.52g. But the values declined considerably with decrease and increase of temperature. Hence a correlation between the number of pod per plant at 50% flowering stage as well as pre harvesting period were established. Macro nutrients e.g. Fe, Zn, Ca, Mg also varied considerably in three cultivars with the increase and decrease of temperature condition. Recent studies have shown that micro- and mega- sporogenesis is injured by high temperature, resulting in reduced fruit set (Cross et al., 2003; Young et al., 2004). High temperature inhibits pollen germination, pollen tube growth, fertilization and embryo development and finally seed development (Huan et al., 2000; Kakani et al., 2002).

The observations as mentioned above was suggestive of a damage caused by freezing and high temperature injury on various physiological and biochemical processes.

Conclusion:

Winged bean like other legumes can withstand high temperature. But with the increase of temperature value of several agronomical parameters decline. Valueof different biochemical parameters and nutritional status of the mature seeds change sharply with the increase and decrease of temperature.

Acknowledgements:

I am grateful to Dr. P. Basu, In Charge of Crop Research Farm, The University of Burdwan for giving me space to cultivate the experimental plant for three years.

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