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Responses of moisture stress on growth, yield and quality of Isabgol (*Plantago ovata* Forsk)

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A pot experiment was conducted during the Rabi season 2006-07 in the green house at Department of Crop and Herbal Physiology, JNKVV, Jabalpur. The experimental design was Completely Randomized Design with seven treatments and three replications to study the effect of moisture stress on growth, yield and quality of *Plantago ovata*. The various treatments exhibited a significantly wide variability in physiological growth determinant, physiological processes, phenological characters, morphological yield attributing parameters and quality parameters of Isabgol. The results showed that in Isabgol moisture stress imposed at emergence to bud formation had the maximum husk (%) and seed yield.

Key words: *Plantago ovata,* Isabgol, moisture stress.

Introduction

Plantago ovata Forsk, the source of Isabgol or blond Psyllium, belongs to the family Plantaginaceae. It comprises of about 200 species, of which 10-14 are natives of India. Its cultivation was originally confined to Lahore and Multan (now in Pakistan) and then it spread to Bengal, Mysore and Coromandel Coast (Husain, 1977). At present, Gujarat is the major Psyllium growing state in the country but grows elsewhere in India. The husk derived from *P. ovata*, also referred to as ispaghul or psyllium mucilloid, widely used as a tool bulking agent for the treatment of constipation. Psyllium husk is obtained by milling the seed of *P. ovata*, and contains a high proportion of a hemicellulose that is composed of a xylan backbone linked with arabinose, rhamnose, and galacturonic acid units. Its laxative effect has been attributed to its ability to form a gel in water (Sandhu and Hudson, 1981). In early

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chemical studies Laidlaw and Percival (1949, 1950) analyzed the polysaccharide mucilage extracted from whole seeds by first cold, then hot water. They secured evidence for two components, which they characterized as a polyuronide and a neutral arabinoxylan. Later Kennedy *et al*. (1979) studied the mucilage obtained from Plantago seed husk by extraction with alkali and concluded that the preparation, although polydisperse, represented a single species of polysaccharide, a highly branched, acidic arabinoxylan.

They are used as a demulcent and as a bulk laxative in the treatment of constipation, dysentery and other intestinal complaints, having a soothing and regulatory effect upon the system (Grieve, 1984; Launert, 1981). Their regulatory effect on the digestive system means that they can also be used in the treatment of diarrhoea and by helping to soften the stool they reduce the irritation of haemorrhoids. The jelly-like mucilage produced when psyllium is soaked in water has the ability to absorb toxins within the large bowel. Thus it helps to remove toxins from the body and can be used to reduce auto-toxicity (Chopra *et al*., 1986). The oil in the seed embryo contains 50% linoleic acid and has been used as a preventative of atherosclerosis. It is also effective in reducing cholesterol levels in the blood (Chevallier, 1996).

The husk has the property of absorbing and retaining water and therefore, it works as a Diarrhoea drug. It is beneficial in chronic dysenteries of amoebic and bacillary origin. It is also used for treating constipation and intestinal disorders because it works calorie free fiber food, protein regular bowel movement. It is reported to have no adverse side-effects. The seed has also cooling demulcent effects and is used in Ayurvedic, Unani and Allopathic system of medicine. The seed is sweet, astringent, refrigerant, emollient, mucilaginous, diuretic, laxative, anti-inflammatory, dysenteric, expectorant, aphrodisiac, roborant and tonic (Zargari, 1994). The seeds and husks are used in inflammations of the mucous membranes of gastro-intestinal and genito-urinary tracts, due to ulcers, gonorrhea and piles. It can also be used as a cervical dilator for the termination of pregnancy. In addition to these medicinal uses, it has a place in dyeing, calico printing, in the ice-cream in as a stabilizer also in confectionery and cosmetic industries. The seed without the husk, which contain about 17-19% protein is used as cattle feed. The seed husk contains colloidal mucilage (30%), mainly consisting of xylulose, arabinose, galacturonic acid with rhamnose and galactose etc. The seed (embryo) yield 14.7% of a linoleic acid –rich oil and small amounts of glycoside acubin and tannin (Pouryousef *et al*., 2007). In the present work, we investigate the possible effect of moisture stress treatment on the physiological and biochemical parameters of Isabgol.

Materials and methods

The pot experiment was conducted at Botanical Garden in the Department of Crop and Herbal Physiology, JNKVV, Jabalpur (M.P.) during the *Rabi* (winter) season of 2006-07. The experiment design was Complete Randomized Design (CRD) with seven treatments and three replications. Sowing and harvesting were done in the month of October and February respectively. Variety of Isabgol was JI 4.

Soil characteristics

The pot experiment soil was loamy sand in texture, low in organic carbon (0.60%), available nitrogen (27 kg ha^{-1}) and medium in available potash (300 kg ha^{-1}) with pH (7.5) which was neutral in reaction.

Treatments Detail and Experimental Design

The design of the experiment was completely randomize design with seven treatments of moisture stress with three replicates. The treatments were as follows: T_1 (Moisture stress imposed at emergence to leaf initiation), T_2 (Moisture stress imposed at leaf initiation to bud formation), T_3 (Moisture stress imposed at emergence to bud formation), T_4 (Moisture stress imposed at bud formation to initiation of flower), T_5 (Moisture stress imposed at initiation of flower to fruit formation), T_6 (Moisture stress imposed at fruit formation to ripening stage) and T_7 (Control condition).

Sampling

Sampling was done at different stages of growth analysis, phenological observation and biochemical parameters. The sampling was done at emergence to leaf initiation, leaf initiation to bud formation, emergence to bud formation, bud formation to initiation of flower, initiation of flower to fruit formation, fruit formation to ripening stage and control condition of Isabgol. Three plants were randomly selected from each treatment and its replication for growth and biochemical analysis was done.

Growth Parameters

Leaf Area Index, Leaf area duration and Photosynthesis parameters were determined by using Infra Red Gas Analyzer of LI-COR Model LI-6400 portable photosynthesis system, USA. The biochemical estimation of *Plantago ovata* seeds i.e. moisture, ash, fat and fibre were carried out by standardized methods of analysis (Thinmaiah, 1999). Nitrogen and protein by micro Kjeldhall digestion and distillation method as given by (AOAC, 1980 Carbohydrate was estimated by Phenol Sulfuric method (Sadasivam and Manickam, 1992), mucilage percentage and swelling factor was determined (Thanki and Talati, 1983).

Results and discussions

The various moisture stress treatment exhibited the significant influences over growth parameters of Isabgol. The Leaf Area Index (LAI) and Leaf area duration (LAD) varied significantly among the moisture stress treatments imposed at different growth stages. Significantly maximum LAI was recorded in T_7 (1.060) and minimum in T_5 (0.540). This increase in photosynthetic surface area might be ascribed to overall improvement in plant vigour, vigor and production of sufficient photo-assimilate through increase in leaf area. Similarly significantly higher LAD was noted in T_2 (27.627) and lower in T_5 (20.427). The increase in leaf area duration might be due to maximum expression of assimilatory.

Crop growth Rate (CGR) and Relative growth Rate (RGR) were noted significantly highest in T_7 (18.603 and 0.149) and lowest in T_3 (15.900) and T_1 (0.116) respectively. Rodriguez, *et al.* (2005) reported that water stress reduced RGR in *Asteriscus maritimus* plants. This might be due to the effect of stress on stomatal closure and/or photosynthetic apparatus. Sanchez *et al.* (2001) suggested that photosynthesis could be a growth limiting factor under drought conditions. The results showed that significantly highest NAR was recorded in T_1 (17.031) and lowest in T_3 (15.632). Higher NAR indicates high photosynthetic efficiency of the treatments (Table 1). The decrease in NAR could be related to stomatal closure during the high levels of stress by Siemens and Zwiazek (2003).

Table 1. Variation of moistures stress on Growth Analytical parameters

Treatment	LAI	LAD (days)	CGR ($gm^{-2}d^{-1}$)	RGR ($gg^{-1}d^{-1}$)	NAR ($gm^{-2}d^{-1}$)
T_1	0.630	22.813	17.850	0.116	17.031
T_2	0.850	27.627	16.870	0.133	16.834
T_3	0.630	23.530	15.900	0.146	15.632
T_4	0.710	24.027	16.970	0.141	16.421
T_5	0.540	20.427	16.880	0.138	16.840
T_6	0.640	22.840	17.103	0.119	15.896
T_7	1.060	23.050	18.603	0.149	16.479
Mean	0.723	23.473	17.168	0.135	16.448
SEm±	0.006	0.016	0.007	0.001	0.001
C.D.	0.018	0.047	0.021	0.002	0.002

Physiological observations

The results revealed that stomatal conductance and transpiration rate varied significantly among various treatments. Significantly maximum were registered in T_5 (3.967) and T_4 (1.750) and minimum were registered in T_1 (1.153 and 0.473) respectively. Similarly Net Photosynthesis and water use efficiency (WUF) varied significantly among various. Significantly maximum was registered in T_5 (8.807 and 7.97 $x10^{-4}$) and minimum in T_1 (1.247) and T_2 ($1.67x10^{-4}$) respectively (Table 2).

Table 2. Variation of moisture stress on Physiological parameters

Treatment	Stomatal conductance ($mmol.m^{-2}s^{-1}$)	Transpiration rate ($mmol.m^{-2}s^{-1}$)	Net Photosynthesis ($\mu mol.m^{-2}s^{-1}$)	WUE (10^{-4})
T_1	1.153	0.473	1.247	2.84
T_2	1.490	1.240	2.070	1.67
T_3	1.847	0.943	1.680	1.79
T_4	2.663	1.750	3.667	2.10
T_5	3.967	1.123	8.807	7.97
T_6	3.607	0.510	2.723	5.46
T_7	3.337	1.372	4.659	3.39
Mean	2.580	1.059	3.550	3.60
SEm±	0.128	0.075	0.196	0.43
C.D	0.388	0.226	0.596	1.29

Phenological development and yield component

The results revealed that the number of silique per plant varied significantly among the treatments. Significantly maximum number of silique was registered in T_2 (285.00) and minimum in T_4 (150.33). Similarly significantly maximum seed weight per plant was registered in T_7 (1.39) and minimum in T_4 (0.59). Maximum harvest index was recorded in T_2 (23.01) which is at par with T_6 (23.00) and minimum was registered in T_1 (20.63) (Table 3).

Table 3. Variations of moisture stress on Phenological and yield component

Treatment	No.of silique per plant	Seed weight per plant (g)	Harvest Index (%)
T_1	232.00	0.81	20.63
T_2	285.00	1.07	23.01
T_3	276.33	0.7	21.61
T_4	150.33	0.59	21.02
T_5	250.33	1.21	21.29
T_6	253.67	1.18	23.00
T_7	267.00	1.39	22.00
Mean	244.95	0.99	21.79
SEm±	26.18	0.16	0.49
C.D	79.42	0.48	1.50

Biochemical parameters

The results revealed that ash and moisture varied significantly among various treatments. Significantly maximum ash and moisture were registered in T_7 (8.000) and T_1 (4.500) and minimum was registered in T_1 (3.000) and T_4 (0.600) respectively. Significantly maximum fat and carbohydrate were registered in T_6 (8.333 and 10.630) and minimum in T_4 (5.000) and T_1 (5.680) respectively. The maximum nitrogen and protein were registered in T_7 (1.518 and 9.490) and minimum in T_1 (1.093 and 6.833) respectively. Similar findings were reported by Hare et al., (1998) that the water stress led to an increase in sugar and total carbohydrates concentrations in seed dry weight as compared with nonstressed control plants of two *Lupinus species*. Khalid (2006) also reported that total carbohydrate of *Ocimum spp*. increased under water stress. Similarly maximum Husk and swelling factor were registered T_3 (55.970) and T_7 (10.500) and minimum were registered in T_2 (39.880) and T_5 (9.900) respectively (Table 4).

Table 4. Variation of moisture stress on biochemical parameters

Treatment	Ash (%)	Moisture (%)	Fat (%)	Carbohydrate (%)	Nitrogen (%)	Protein (%)	Husk (%)	S F. (mg/ml)
T_1	3.000	4.500	7.000	5.680	1.093	6.833	41.940	10.10
T_2	5.000	3.000	7.667	8.320	1.258	7.860	39.880	10.00
T_3	5.503	2.000	8.000	6.930	1.385	8.657	55.970	10.20
T_4	6.000	0.600	5.000	10.230	1.311	8.193	44.020	10.40
T_5	3.633	0.900	8.000	9.830	1.452	9.077	44.180	9.90
T_6	4.003	0.800	8.333	10.630	1.302	8.140	41.180	10.30
T_7	8.000	1.000	8.000	8.490	1.518	9.490	40.280	10.50
Mean	5.020	1.829	7.429	8.587	1.331	8.321	43.921	10.20
SEm±	0.314	0.421	0.604	0.480	0.400	0.437	2.433	0.57
C.D	0.954	1.277	1.833	1.456	1.232	1.325	7.381	1.73

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