SCREENING AND DEVELOPMENT OF BLAST RESISTANT RICE VARIETIES FOR KASHMIR VALLEY

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ABSTRACT

In the past several decades many varieties of rice were developed by Rice Research and Regional Station, Khudwani with improvements over the existing ones. In 2007, rice blast disease (*Pyricularia oryzae*) took serious dimensions in the valley of Kashmir and hence the main emphasis was shifted on developing high yielding blast resistant varieties of rice for Kashmir valley. Keeping in view this objective, a number of genotypes were screened in kharif 2008 for blast resistance under field conditions at RR&RS, Khudwani and scored on 0-9 scale. These include 300 germplasm entries, 60 genotypes (comprising of promising entries, pre-released and released varieties), and national & international paddy blast differentials. Six entries of germplasm were found highly resistant to leaf blast and 40 to neck blast (blast score 1). Amongst the 60 genotypes, 27 genotypes were resistant to leaf and neck blast (blast score of 2) and two genotypes (SKAU 341, Vivekdhan 82) were highly resistant (blast score 1) while the rest had score higher than 2. With the objective of breeding for resistance these resistant genotypes were involved in crosses during Kharif 2008 and 2009. In addition, crosses between Jhelum (Susceptible variety) and low scoring (Blast score 0-1) International blast differentials and entries from International Rice Blast Nursery (C101-A51, A57, C101-PKT, NP125, USEN, Tadukan, HR 12, Rasi, IRBL1-CL, IRBLKS-S, IR78222-20-7-50-2-B, B-40) were also attempted successfully. During kharif 2009 and 2010 the segregating generations were raised in field and selection for disease tolerant genotypes was made for further advancement to next generations.

***Key words*:** Rice, Kashmir valley, germplasm, disease management, genotypes

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for more than half of the world's population. Demand for rice continues to increase due to the ever-increasing rice consumer base. However, the present rate of increase in rice production (2000-09) has slowed down (1.21%) compared with that of previous decades (1970-90, 2.49%; 1990- 2000, 1.70%) due to various biotic and abiotic stresses (Khush and Jena, *2009*). Among the biotic stresses, blast, a disease caused by *Pyricularia oryzae*, is the most devastating,

leading to a 90% yield loss in rice. *P. oryzae* is a serious pathogen of graminaceous species belonging to at least 22 genera (Farr *et al*., 1989). However, the pathogen is best known as the causal agent of the rice blast disease. The disease is a serious production constraint for rice in the northwestern Himalayan region of India, comprising the states of Jammu and Kashmir, Utranchal and Himachal Pradesh (Sharma *et al*., 2002).

Rice is a staple food of the Kashmir Valley and is cultivated within an altitude range of 1,500–1,800 m above mean sea level. The advent of semidwarf high- yielding varieties in the region during the last two and half decades has revolutionized rice production (Sanghera *et al.,* 2010). However, blast disease is endemic to most rice growing areas of Jammu and Kashmir due to prevailing blast-conducive environmental conditions during the crop season. In 2007, rice blast disease took serious dimensions in the valley of Kashmir with Mushk budgi, an early maturing aromatic variety of Kashmir, being highly susceptible (Husaini *et al.,* 2009). Although, chemical control of the disease is feasible, it remains economically impractical for resource poor farmers and is environmentally undesirable. Since host resistance offers cost effective and eco-friendly method for disease management, present study was conducted to identify the promising entries resistant against *Pyricularia oryzae* with the objective of introgressing blast resistance in otherwise blast susceptible varieties of rice, that are widely cultivated in Kashmir valley.

MATERIAL AND METHODS

Field experiment was carried out at Rice research and Regional Station, Khudwani to record reactions of more than 350 rice genotypes against blast disease under natural conditions. Each test entry was sown as a two row material with 2 m length and spacing between rows as 20 cm. After every 10 test entries local susceptible variety (Mushk budgi) was planted and entire nursery was surrounded on all sides by two rows of susceptible variety. Two observations on leaf blast severity were recorded at 10 days interval starting from 25 DAS. The first observation on neck blast incidence was recorded when heading was completed in test entries and second between milk and dough stage. Evaluation was made by the standard evaluation system of rice on 0-9 scale. The highest grade expressed by each entry out of ten plants scored was considered as its reaction against the disease. The resistant genotypes were involved in crossing programme during Kharif 2008 and 2009. In addition, crosses between Jhelum (Susceptible variety) and low scoring (Blast score 0-1) International blast differentials and entries from International Rice Blast Nursery (C101-A51, A57, C101-PKT, NP125, USEN, Tadukan, HR 12, Rasi, IRBL1-CL, IRBLKS-S, IR78222-20-7-50-2-B, B-40) were also attempted successfully. During kharif 2009 and 2010 the segregating generations were raised in field and selection for disease tolerant genotypes was made for further advancement to next generations.

RESULT AND DISCUSSION

The results revealed that out of 300 germplasm entries only six entries were highly resistant to leaf blast at booting and heading stage (Blast score 1) viz., GS-51, 90, 99, 197, 232 and 299; while five were resistant (Blast score 2) viz., GS-6, 198, 237, 283 and 294 (Table 1). Amongst the 60

Table 1. Screening of local rice germplasm for blast resistance following Standard valuation System under temperate conditions of Kashmir valley

Particulars	Disease score	Entries
Leaf Blast Resistant entries (at booting and Heading stage)	1	GS-51, 90, 99, 197, 232, 299,
	2	GS-6, 198, 237, 283, 294,
	3	GS-55, 56, 59, 61, 62, 63, 64, 70, 71, 91, 93, 95, 96, 97, 98, 155-178, 180, 181, 182, 183, 185, 188, 189, 195, 227, 231, 238
Neck Blast Resistant entries (at maturity)	1	GS- 10, 54, 62, 70, 93, 97, 99, 101, 110, 111, 112, 114, 119, 123, 124, 125, 127, 128, 129, 131, 132, 133, 136-142, 145, 146, 147, 155-162, 176, 178, 188, 190, 195, 197
	2	GS-32, 37, 46,50, 52, 55, 56, 71, 75, 82, 90, 91, 92, 96, 98, 102-109, 113, 115, 117 122, 130, 144, 148, 149, 163, 164, 166, 167, 169, 170, 173, 179, 182, 187, 198
	3	GS-27, 44, 94, 95, 150, 152, 164, 168, 171, 172, 174, 177, 181, 185, 186

genotypes comprising of released and pre-released local & National varieties as well as promising types received from International Network for Genetic Evaluation of Rice (INGER), 27 genotypes were resistant to leaf and neck blast (blast score of 2) and two genotypes (SKAU 341, Vivekdhan 82) were highly resistant (blast score 1) while the rest had score higher than 2 (Table 2). International blast differentials too were scored for disease reaction and A-57 was found to be highly resistant while USEN was resistant (Table 3). Such variation in the response of entries against *P. oryzae* recorded has been also observed by other workers too (Saifulla et al., 1991; Chandrashekara *et al*., 2008).

Table 2. Screening of released and pre-released rice varieties of Kashmir and promising entries received under INGER and ACRIP for blast resistance under temperate conditions of Kashmir valley

Disease score (Leaf & Neck Blast)	Rice varieties
1	SKAU-341, Vivekdhan 82
2	HS-379, IR68333-R-R-B-22 (MS11), 87025-TR973-3-1-1, 9610-TR1749-5-1-1, YUNGEN 9, IRAT 248, 9710-TR1830-4-1-2, SKAU 398, SKAU 400, SKAU 399, 84017-TR-745-12-1, AMAROO, IR62443-2B-4-3-2-3-2-1, YUNLEN-19, RIZABELLA 2, 83025-TR643-1-1-1-1, 82079-TR489-3-1-1, 88018-TR1043-6-2-3-1, Jhelum, Shalimar Rice-1, PRH-10, VL Dhan 62, VL Dhan 86, K 743-1-1, SKAU-382, SKAU-292, SKAU-391.
3	STEJAREE 45, K-450-3-2-2, SKAU 397, 90051-TR1243-2-2-1, Pusa sugandh-5, UPR 2268-5-1, Pusa 2517-2-51-1, IR 72768-15-1-1, WAT 311-WAS-B-23-7-1-1-4-5, IR 53236-77-4, Pusa sugandh-3, VL Dhan 65, VL Dhan 206, VL Dhan 207, VL Dhan 209, SKAU- 353, SKAU 337, SKAU 339, SKAU-354.
4	HSC 16, BG 304, Pusa sugandh-2, IR 71144-393-22-3-1, VL Dhan 154, VL Dhan 208, VL 4561, HPR2309.
5	86014-TR891-7-2-1, 88088-TR1113-4-1-1, Javae.
9	Mushk Budji (Check)

Table 3. Score for blast disease in International Blast Differentials adopting SES scale (0-9), under temperate conditions of Kashmir valley

S. No.	International Blast Differentials	Disease Score (0-9 scale)	S. No.	International Blast Differentials	Disease Score (0-9 scale)
1	C101 LAC	4	**13**	Zenith	5
2	C101 A51	3	**14**	NP125	7
3	C104 AKT	3	**15**	USEN	1
4	C105 TTP 4-1-2-3	3	**16**	Dullar	2
5	RH10	1	**17**	Shia-tia-tsao	4
6	RH29	3	**18**	Tadukan	5
7	Oryza minuta	3	**19**	IR64	6
8	BL122	2	**20**	HR12	2
9	BL245	2	**21**	Rasi	3
10	A-57	0	**22**	Co-Co 39	2
11	C101PKT	2	**23**	Mushk Budji (Susceptible check)	9
12	Raminad str 3	5			

International blast differentials adjudged resistant to prevalent race under natural field conditions (C101-A51, A57, C101-PKT, NP125, USEN, Tadukan, HR 12, Rasi) and promising entries from International Rice Blast Nursery (IRBL1-CL, IRBLKS-S, IR78222-20-7-50-2-B, B-40) were used as donors to transfer blast resistance to the most popular but otherwise susceptible variety, Jehlum and to the high altitude susceptible varieties (Table 4). The F1 seeds generated were advanced to next filial generations for selection breeding. During kharif 2009 and 2010 the segregating F2 & F3 populations were subjected to selection pressure using bombardment rows of the most susceptible variety, Muskh budgi and selection for disease tolerance was made for further advancement to next generations.

Table 4. Crosses attempted for developing blast resistant genotypes

S.No.	Cross Combination	S.No.	Cross Combination
1	Jehlum × C101-A51	15	186014-TR891-7-2-1 × K 508
2	Jehlum × A 57	16	186014-TR891-7-2-1 × Koshihikari
3	Jehlum × C101-PKT	17	186014-TR891-7-2-1 × K 332
4	Jehlum × NP 125	18	87025-TR973-3-1-1 × K 332
5	Jehlum × USEN	19	87025-TR973-3-1-1 × Koshihikari
6	Jehlum × Tadukan	20	87025-TR973-3-1-1 × Ittal
7	Jehlum × HR 12	21	Stijari 45 × K 332
8	Jehlum × Rasi	22	Stijari 45 × Ittal
9	Jehlum × IRBL1-CL	23	HS-379 × K 332
10	Jehlum × IRBLKS-S	24	HSC-16 × K 332
11	Jehlum × IR78222-20-7-50-2-B	25	HSC-16 × Koshihikari
12	Jehlum × B 40	26	HSC-16 × Ittal
13	Jehlum × IR-64	27	Tatsumi-muchi × K 332
14	186014-TR891-7-2-1 × Ittal	28	Tatsumi-muchi × Koshihikari

S. No. 1-8: Crosses between Jehlum and International Blast Differentials,

S. No. 9-13: Crosses between Jehlum and genotypes of International Rice Blast Nursery (IRBN),

S. No. 14-28: Crosses between high altitude *Japonica* genotypes and International types (INGER)

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CRYSTALLURIA OF BOVINE OBSTRUCTIVE UROLITHIASIS UNDER TEMPERATE CONDITIONS OF KASHMIR.

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ABSTRACT

Crystalluria was used to diagnose the disease and evaluate the surgical techniques employed for the management of clinical cases of bovine obstructive urolithiasis. The surgical techniques included tube cystostomy and cystotomy with indwelling urethral catheterization. Tube cystostomy was performed with polyvinyl chloride catheter in 10 cases (group AI) and with Foley's catheter in another 10 cases (group AII). Cystotomy with indwelling urethral catheterization was also performed in 10 cases (group B). Heavy crystalluria was recorded in the animals of all groups on the day of admission. Postoperatively the crystal score showed progressive declining trend with the result the score was mild by 48 hours in the animals of group AII and by 168 hours in the animals of group AI and B. Triple phosphate crystals were found in all the urine samples (alone in 75% samples and in combination with other types of crystals in 25 of samples). Other types of crystals like calcium oxalate, hippuric acid, calcium carbonate and uric acid were found as minor components of triple phosphate crystalluria in these samples. Crystal morphology was highly variable. Broadly struvite crystals were categorized into prism shaped and fern like or feather shaped. Cystalluria proved effective in diagnosis and monitoring the management of the disease.

***Key words**:* Urolithiasis, crystalluria, calf, tube cystosotomy

INTRODUCTION

Obstructive urolithiasis is considered one of the major causes of economic loss to livestock owners. According to one study, it has been attributed to be the 5th most prevalent cause of death in feedlots (*Salman*, *1988*). Obstructive urolithiasis is often difficult to detect until it is life threatening because the clinical signs can be quite variable depending upon duration, extent (partial or complete) and location of obstructing urolith. Crystalluria is a frequent finding in the routine examination of urine sediment. Crystalluria is associated with pathological conditions such as urolithiasis, acute uric acid nephropathy, ethylene glycol poisoning, and hypereosinophilic syndrome. Additionally, crystalluria can also be due to drugs such as sulphadiazine (*Fogazzi, 1996*).

Since different crystals have different appearances, so microscopical examination of urine sediment has diagnostic importance for the diseases of urinary system (*Barlough et al., 1981*). The crystal number is of greater significance than crystal shape and size (*Khan and Hackett, 1987*). The aetiopathogenesis of obstructive urolithiasis is determined by the chemical composition of uroliths. The chemical composition of urinary calculi varies according to geographical and mangemental conditions and depends largely on the dietary composition of individual elements. Knowing the chemical composition of urolith is also imperative for successful management of urolithiasis. The chemical composition of urolith can be readily identified by recording the number and shape of crystals. This study was thus contemplated to evaluate the efficacy of crysalluria as a diagnostic and monitoring aid for bovine obstructive urolithiasis under temperate conditions of Kashmir.

MATERIAL AND METHODS

Thirty male cattle calves, suffering from complete retention of urine, presented for treatment at Teaching Veterinary Clinical Services Complex, Faculty of Veterinary Sciences and Animal Husbandry (F. V. Sc & A. H.), Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K), Srinagar, formed the material of the study. Ten bovine clinical cases of obstructive urolithiasis each were subjected to tube cystostomy using polyvinylchloride urinary catheter (Group AI), tube cystostomy using Foleys catheter (Group AII) and cystotomy with normograde cystourethral catheterization {(cystotomy with indwelling urethral catheterization) (Group B)}. Five ml urine samples were collected aseptically during the operation from opened abdomen or urinary bladder, and from the tube cystostomy catheter (Group AI and AII) and urethral catheter (group B) postoperatively on 24, 48, 96 and 168 hours. The urine samples were centrifuged at 3000rmp for 5 minutes. The supernatant from the centrifuge tube was decanted. The tube was placed in an upright position to drain the urine of the sides to the bottom. The sediment was mixed with this residual urine by striking the bottom of the tube with a finger. A drop of mixed sediment was put on a glass slide and a cover slip was placed over it. The slide was examined under the microscope for the presence of crystals under low power (10X) and the quantity was graded as 0 normal crystals (0-2 crystals per field), 1-mild (2-5 crystals per field), 2 moderate (5-10 crystals per field), 3 heavy crystals (>10 crystals per field). The mean score of 0 was considered as no crystals, 0-1 as mild, 1-2 as moderate and 2-3 as heavy crystals for the interpretation of results. Identification of crystals and their confirmation was made as per the standard procedure (*Benjamin, 1985*).

RESULTS AND DISCUSSIONS

The presence of crystals in urine can be of no clinical significance in health, but in animals with histories of urolithiasis or relevant clinical signs they may be significant. Large numbers of crystals in dilute urine,

persistent crystalluria and large crystals have greater significance in relation to stone formation. Crystal formation is affected by mineral composition and pH of urine. Crystals can precipitate while urine is still in the urinary system or after micturation when changes in temperature and/or pH can occur upon standing. Heavy score of crystals was recorded in the animals of all groups on the day of admission without any significant difference among them (Table 1 and Fig 1).

Table 1. Mean ± SE score for crystals in urine in calves of different groups

Group	Post operative interval (Hours)				
	0	24	48	96	168
AI	2.5 ± 0.16	2.2 ± 0.20	1.8 ± 0.20*	1.3 ± 0.15*	0.9 ± 0.18*
AII	2.5 ± 0.17	1.6 ± 0.16^{*x}	0.9 ± 0.18^{*x}	0.6 ± 0.16^{*x}	0.4 ± 0.16*
B	2.5 ± 0.17	2.0 ± 0.26	1.6 ± 0.22^{*y}	1.3 ± 0.26^{*y}	0.7 ± 0.30*

Values with Superscript* are significantly (P<0.05) different from the corresponding base valus
Values with Superscript^{x} are significantly (P<0.05) different from AI value at the corresponding interval
Values with Superscript^{y} are significantly (P<0.05) different from AII value at the corresponding interval

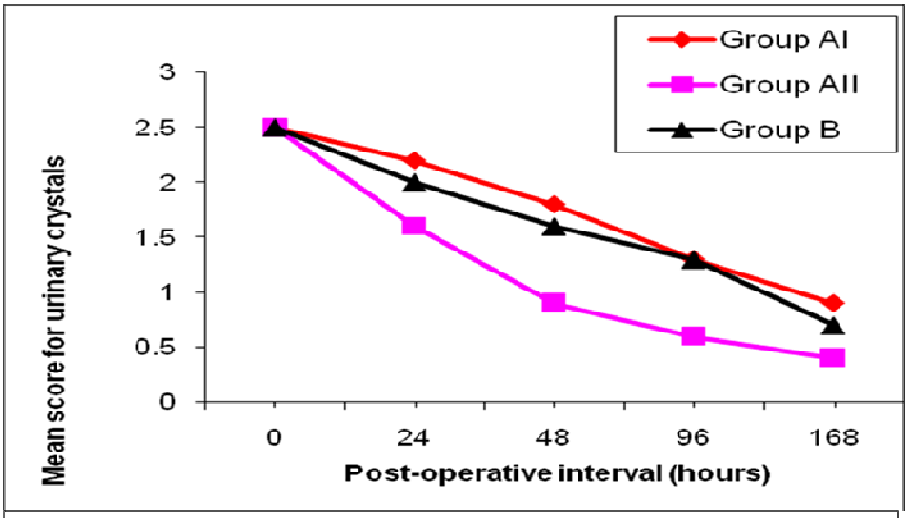

Fig 1: Mean score for urinary crystals in calves of different groups

Heavy crystalluria on the day of admission in all the groups suggests that the urine was saturated and could have precipitated the development of urolithiasis (Radostits et al., 2000). Varying degree of dehydration present in all the animals on the day of admission could has raised the relative concentration of urinary mineral solutes and increased the likelihood of their precipitation (Bezeau et al., 1961; Smith and Sherman, 1994; Larson, 1996).

Postoperatively the crystal score showed progressive declining trend. Of the three groups, the animals of group AII showed faster decrease in crystal score followed by group B and AI respectively. In group AII animals the score was moderate on 24 postoperative hour and mild thereafter. In animals of group B

though the score was mild on 168 postoperative hours, it was moderate from 24-96 postoperative hours. Similarly in the animals of group AI the score remained heavy up to 24 hours and moderate upto 96 postoperative hours. Comparison among the groups revealed that the crystal score of group AII was significantly ($p<0.05$) lower than that of AI at 24 postoperative hours and significantly ($p<0.05$) lower than score of both the groups at 48 and 96 postoperative hours. Post-operative decrease in the level of crystal score could be attributed to the dilution of urine affected by intravenous administration and oral intake of fluid. The quick decline in crystal score in the animals of group AII could be attributed to early regain of appetite and less irritation of urinary bladder by Foley's catheter.

In total seven types of crystals with different shapes were recorded (Table 2).

Table 2. Percentage of different crystals in urine in calves. N = 30

S. No	Type of crystals	No. of samples	%age	Shape of crystals
1.	Triple phosphate	23	76.66	Prismatic, elongated rod, coffin lid shaped, star shaped, feathery or fern like.
2.	Calcium/Amorphous phosphate	2	6.66	Spherical, Granules in masses, amorphous
3.	Calcium carbonate	1	1.33	Amorphous, granular
4.	Calcium oxalate	1	1.33	Small squares crossed by 2 intersecting diagonal lines
5.	Hippuric acid	1	1.33	Prism
6.	Tyrosine	1	1.33	Fine needles
7.	Uric acid	1	1.33	Rosette shaped

Triple phosphate or struvite (magnesium ammonium phosphate) crystals were detected in the urine of every animal. The crystals were found alone in 23(74.65%) urine samples and in combination with other types in 7 (23.35%) samples. Calcium phosphate crystals were relatively less frequently recorded, only in 2 (6.66%) cases. Calcium carbonate, calcium oxalate, hippuric acid, tyrosine, uric acid and cystine crystals constituted only minor proportion and were found in one animal each. In most instances the precipitation of crystals of calcium oxalate, uric acid, triple phosphate, calcium phosphate and amorphous phosphates or urates is caused by transient supersaturation of urine, ingestion of specific foods, or by changes of urine temperature and/or pH which occur upon standing after micturation. In all the cases, where phosphate crystalluria was observed, urine pH was alkaline and the feeding schedule constituted mostly concentrates and wheat bran with low roughage. Alkaline pH of urine favours the

precipitation of calcium and magnesium phosphates and carbonates, triple phosphates crystals (Powe*,* 1986). Feeding of high concentrate, low roughage diet resulting in low Ca: P ratio (Ahmed et al., 1989) also favours the precipitation of triple phosphate crystals (Larson, 1996).

Crystal morphology was highly variable. Broadly struvite crystals were categorized into prism shaped and fern like or feather shaped crystals. The most common shape of struvite was rectangular coffin lid and prism with 3 to 6 or more sides and often have oblique ends, a few of them had broken ends. Other common shape was orthorhombic having three unequal axes intersecting at right angles. Struvite crystals also appeared in plus (+), cross (x), 'T' shaped and aggregated form giving a star shape to the crystal (Figs. 2-8). In few urine samples rod shaped triple phosphate crystals were observed (Fig. 9). Planar or X-shaped morphology of struvite crystals indicate rapid growth while misshapen or octahedral shape shows slowed growth rate (Mclean *et al.*, 1991). These observations corroborated the findings of Oser (1965) and Osborne *et al.* (1990). Calcium phosphate crystals were spherical, granular or amorphous and often seen as a cluster (Fig. 2). Occurrence of mixed crystals of struvite with calcium phosphate crystals is acceptable as both types of crystals prcipitate in alkaline pH. Calcium carbonates were of spheroids with radial striation, or smaller crystals with rounded or ovoid end (Fig. 3). The common shape of calcium oxalates was square with corners connected by intersecting diagonal lines (Figs. 4 & 5). Hippuric acid crystals were elongated hexagonal that were connected by rounded corners (Fig. 6). Tyrosine crystals had the needle shaped appearance (Fig. 7). Uric acid crystals were rosette and barrel shaped (Fig. 8). Hippuric acid, calcium oxalate, calcium carbonate and tyrosine crystals recorded in this study were found in acidic pH, thus confirming the observations of Osborne *et al*. (1995). The findings are also in conformity with those of (Singh, 2005), who also recorded struvite crystals with coffin lid appearance; calcium oxalate monohydrate crystals with picket fence appearance, envelope ditetragonal pyramids/bipyramidal shape, while as calcium oxalate dihydrate crystals had a maltese cross or square envelope shape . Urate crystals are thorn apple or fine needle shape and cystine crystals are of hexagonal shape (Escolar *et al.,* 990; Dibartola, 2000). The urine of a goat fed on a diet containing calcium and oxalic acid was found to contain numerous cuboidal bipyramidal; and unique rectangular parallel piped COD crystals (Clark *et al.,* 1999).

CONCLUSIONS

Crystalluria can be effectively used to diagnose and to monitor the efficacy of different treatment regimes to be employed both for therapeutic and prophylactic purposes. Moreover the crystalluria could be beneficial in studying the aetiopathogenesis of the disease and chalking out its managemental procedures.

Fig.2. Amorphous phosphate (open arrow head) and triple phosphate crystals in urine sediment.

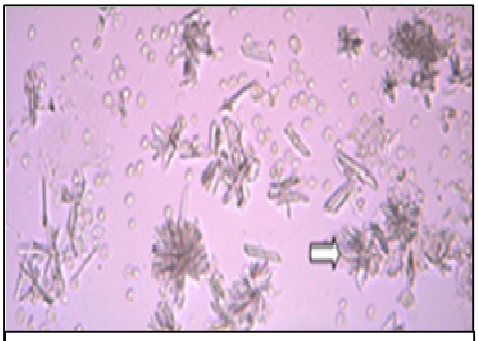

Fig.3. Fern like triple phosphate (open arrow head) and calcium carbonate (black arrow) crystals in urine sediment.

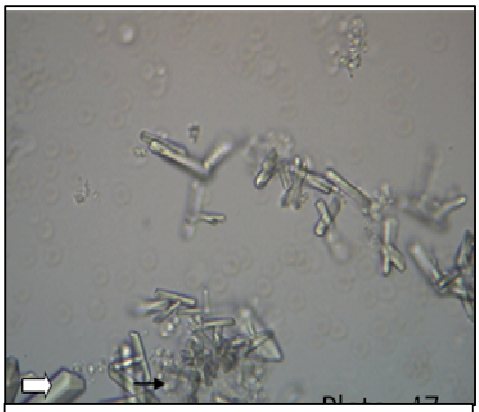

Fig. 4. Prismatic triple phosphate (open arrow head) and calcium oxalate (black arrow) crystals in urine sediment.

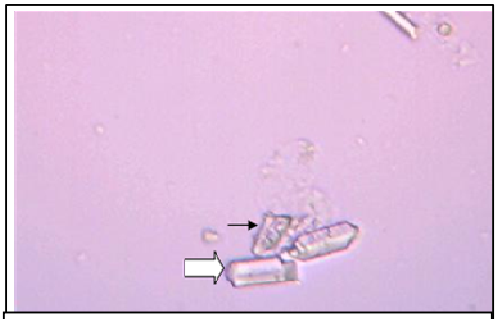

Fig.5. Prismatic triple phosphate (open arrow head) and calcium oxalate (black arrow) crystals in urine sediment.

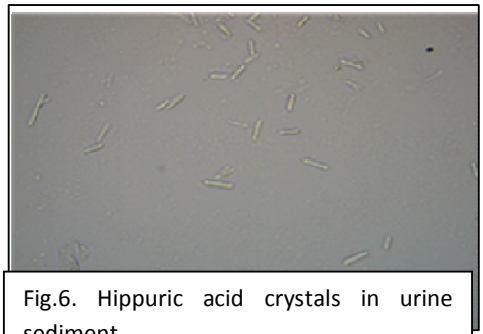

Fig.6. Hippuric acid crystals in urine sediment.

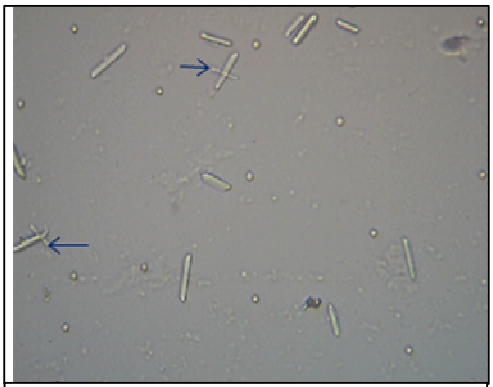

Fig.7. Triple phosphate and needle shaped tyrosine (black arrow) crystals in urine sediment

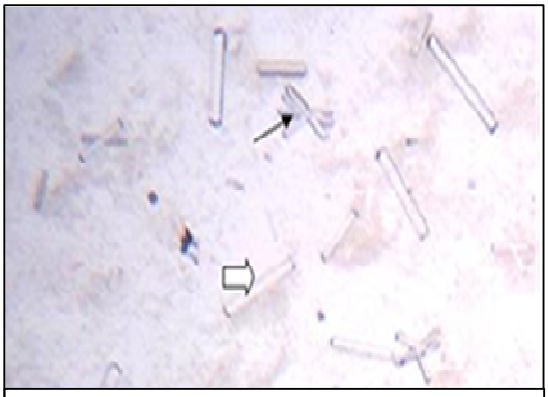

Fig.8. Triple phosphate (open arrow head) and uric acid (black arrow) crystals in urine sediment.

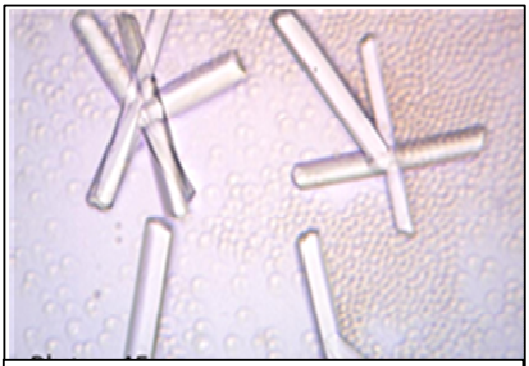

Fig.9. Rod shaped triple phosphate crystals in urine sediment.

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STATUS OF PULSE CROP DISEASE IN J&K STATE AND THEIR INTEGRATED MANAGEMENT

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ABSTRACT

Pulses are an important component farming systems after cereals. Main constraints of decline in pulse production in Jammu & Kashmir are the serious diseases caused by fungi, virus and bacteria. Various disease affecting pulse crops are Angular leaf spot, Alternaria blight, Anthracnose, Common bean mosaic virus and common bacterial blight with the result there is considerable reduction in yield and production. The present review paper tempted the author to compile the status of pulse crop diseases and their management as earlier information was scanty.

Key words: Pulses, status, diseases, management

INTRODUCTION

Jammu & Kashmir state has witnessed the most spectacular change in the total agricultural and horticultural output in the last three decades. Although all components of food grains and fruits showed phenomenal increase in the production, the magnitude of pulse production has not been proportionate to cereals and fruits. As a result, there availability has declined sharply leading to rise in their prices.

Pulses are an important component of farming system both ecologically and in terms of human and animal nutrition. Over a dozen pulse crops including kharif and rabi grown annually in different parts of the country in around 22-23 million hectares, producing 13 to 15 million tonnes of grains, but in J&K state mainly pulses like beans, mong, cowpea, soyabean, pea, lentil and chickpea are grown. During 2007-2008 in India the total production of pulse was 14.76 million tonnes from an area of 23.63 million hectares with the domestic production requirement of 17-18 million tonnes annually to meet the demand (Gupta, 2009). In J&K state pulses are grown on an area of 29.06 thousand hectares with the production of 141 thousand quintals (Anonymous, 2007).

Although World Health Organization recommends the consumption of 80 gm per capita of pulses every day for Indian, while it is very less consumed in J&K state. Pulses are the most important constituents of our meals. However, the prices of pulses have sky-rocketed over the last few years making life difficult for the poor. One of the important reasons behind the price rise has been the fact that over the years the

production of pulses has declined due to attack of disease and insects. Around 8-10 per cent crops are annually lost due to ravages of diseases alone costing nearly 1000 crores to the National Exchequer Reduction of losses caused by diseases is therefore, an important component of the crop production technology. Integrated disease management (IDM) is the only answer to combat the huge losses. IDM encourages the most compatible and ecologically sound combinations of available disease suppression techniques to keep the incidence/intensity of diseases below economically damaging levels.

DISEASE PROBLEMS

Like other cereals and legumes the pulse crops are prone to attack by a large number of plant pathogens. Among these fungi, virus and bacteria are very important and causes diseases which are of economic significance. Beans, moong, cowpea, pea, lentil, chickpea are the main pulse crops in J&K which are affected by number of pathogens.

Table.1. Major diseases affecting pulse crops in J&K

Crop	Disease	Pathogen
Beans	Angular leaf spot	*Phaeoisariopsis griseola*
(*Phaseolus vulgaris* L.)	*Alternaria* blight	*Alternaria alternata*
	Anthracnose	*Colletotrichum*
	Wilt	*lindemuthianeum*
	Root rot	*Fusarium oxysporum* f.sp.
	Bean common mosaic virus	*Rhizoctonia solani* phascola
	Common bacterial blight	Bean common mosaic virus
Moong	Rust white mold or white rot	*Uromafecs vicial*
(*Vigna radiata*)	Leaf spot (*cercospora*)	*Sclerotinia sclerotiorum*
	Alternaria blight	
	Yellow mosaic virus	
Cowpea	Leaf spot (coryneaspora)	*Coryncasfiora* sp.
(*Vigna sinensis*)	*Alternaria* blight	*Alternaria alternate*
Pea	*Ascochyta* blight	*Ascochyta pisi*
(*Pisum sativum*)	Powdery mildew	*Erysiphe pisi*
	Alternaria blight	*Alternaria alternata*
	Wilt	
	Septoria blight	
	Anthracnose	
Lentil	*Alternaria* blight	*Ascochyta lentis*
(*Lens culinaris* L)	*Ascochyta* blight	
Chickpea	Wilt ascochyta blight	*Fusarium oxysporum*
		Ascochyta rabici
Faba beans/ broad beans	Wilt	
(*Vicia faba*)	Root rot	

Resume of Research Work In J&K

The first published report on prevalence of some fungal diseases of pulses in Kashmir is by Kaul *et al*., (1988). Studies conducted during 1986 and 1987 revealed that pod and leaf blight (Alternaria alternata, Ascochyta lentis) cause heavy damage to *rabi* lentil (*Lens esculentus*) with 12 to 18 per cent disease severity. Foot/root rot (*Fusarium solani*) of rajmash (*Phaseolus vulgaris)* was recorded in traces, while blight (*A. alternata*) was severe ranging from 55-70 per cent on commercial types. However, root rot (*Sclerotium rolfsii*) was recorded in traces on a local red type. Incidence of *Caryneospora* sp. and *Alternaria alternata* at maturity stage lead to leaf and pod blight to an extent of 57 per cent on cowpea (*Vigna sinensis*). Studies on virus diseases of rajmash bean (*Phaseolus vulgaris* L.) in Kashmir was conducted during 1998-89 (Bhan, 1991) in the bean growing areas of the valley. In order to record the incidence of various virus diseases on the basis of symptoms. Studies revealed that the bean common mosaic disease was prevalent in almost all the surveyed areas with an average incidence of 8.2 per cent. The symptoms resembling to those of bean yellow mosaic disease were observed with an average incidence of 2.9 per cent. The BCMV diseased plants showed light and dark green mosaic pattern on the leaf surface. The dark green areas of the leaf were pucked and curled from the margins giving the plants a wilted appearance. The infected plants produced pods of smaller size. The pod length was reduced by 55 to 60 per cent.

The bean common mosaic virus disease was transplanted mechanically by rub inoculation through sap from the infected plants, by starmed aphids (*Aphis craccivara*) and through seed. *Chenopodium amaranticolor* proved to be the best indicator host plant for the biological identification of the virus. The dilution end point of the virus was determined to be between 1: 10, 000 to 1: 50,000, longevity *in vitro* at room temperature (15-18^{0}C) between 48-60 hours and thermal inactivation point between 60-65^{0}C. The contender and Kentucky wonder bean varieties have shown resistance to the disease besides few breeding lines (HVR 15, PDR 14, HVR 67, HVR 120, HVR 63) obtained from the pulse directorate, Kanpur

Interaction of *Phaeoisariopsis griseola* and *A. alternata* in bean (*P. vulgaris* L.) (Kotwal, 1994) revealed maximum disease incidence of angular leaf spot ranging from 90.92 to 92.32 per cent and that of *Alternaria* leaf spot from 40.58 to 41.34 per cent on contender variety of beans. Similarly the maximum disease intensity of angular leaf spot diseases ranged from 52 to 55 per cent and that of *Alternaria* leaf spot from 25 to 55 per cent on contender. Maximum growth of both the pathogens was recorded on PDAB and honey peptone agar medium. The angular leaf spot disease progressed very rapidly with temperature range of 18.85 to 18.41^{0}C and relative humidity range of 64.42 to 53.25 per cent. The temperature range of 18.14 to 20.90 and relative humidity range of 53.25 and 84.50 were most suitable for *Alternaria* leaf spot disease on beans. The cvs. namely Arha komal red and local

climbing type recorded resistance to both the diseases. The highest yield of 9.75 q/ha with maximum control of both the diseases was recorded with mancozeb followed by 11:1 with Zineb and 5.6:1 was recorded with copper oxychloride treatments.

Identification and elucidation of *Ascochyta rabiu* isolates of chickpea was investigated in Jammu (Ambardar & Singh 1996). Interaction of treatments were broadly categorized into 18 groups based on the morphological and cultural variations. The isolates were named according to varieties/lines from which they were collected. Test isolates exhibited large variation in morphology and cultural characters, light to dark, pink and grey colony colors were predominant. The maximum colony growth was obtained for the isolate ICC 88318, whereas, the minimum for the isolate C 325 (B). The isolated C 235, A, B and K exhibited less sporulation, while the remaining isolates recorded good to abundant sporulation. Variation in the pycnidial size was more than in pycniospores ten pathotypes namely 1 (4032), 2 (4088), 3 (3904), 4 (4018), 5 (3522), 6 (1888), 7 (3904), 8 (3800) 9 (1408) and 10 (3968) were identified. The differential ICC 1467 was found resistant and PBT revealed susceptible to all the 18 isolates tested. For Ascochyta blight management in chickpea Ambardar & Singh (1995) Found that highest yield was obtained from treatment T8, when chickpea variety C 235 was sown late in December with carbendazim + thiram (1:2) seed treatment followed by three sprays including two sprays (I and III) of zineb and one spray (II) of carbendazim and thiram (1:2 ratio). The next higher yield were obtained from T6 and T4 treatments T1, T5, T9 and T11 were non-significantly different from each other with susceptible variety L 550 sown either in November or December with or without seed treatment. Epidemiology and management of major foliar diseases caused by fungi in field peas was studied by Dhar (1995). Disease incidence and severity of major fungal foliar diseases of field pea in Kandi of Jammu division during rabi 1993-94 revelaed that both the field pea cultivars namely T-169 and Rachna ranked more or less in a similar way to the major foliar diseases viz., Rust *Alternaria phoma* blight and downy mildew. The maximum severity of powdery mildew (70.66%) and rust (40%) was recorded from cultivar KFDD-1 and that of *Phoma* (46.66%) and *Alternaria* blight (41.33%) from cultivar T-163. The maximum severity of powdery mildew disease (32%) was recorded from cultivar Rechna.

The favourable weather conditions such as temperature (19.60 to 27.71^{0}C) during the day and cool nights (2.80 to 8.80^{0}C) were suitable enough for dew formation. Scanty rainfall (0.00 – 9.21 mm) and regular sunshine (3.17 to 9.21 hr) prevailed from appearance of major fungal diseases till harvest of the pea cultivars and resulted in increase in the severity of all the foliar fungal diseases. Out of seventy five pea germplasm lines screened under field conditions, a few of them recorded resistant under natural conditions to two diseases i.e. DMR-24, KFPO-18 and DPFPD-2 to powdery mildew and rust, DMR-26 to powdery mildew and *Alternaria* blight KPMP-322, KPMR-316 to

rust and *Alternaria* blight. The highest grain yield (9.17 q/ha and the maximum reduction in all the major foliar disease powdery mildew, rust, *Alternaria* and *phoma* blight were recorded from T17, when seeds of variety Rachna were treated with mancozeb and later the crop was sprayed with two sprays each of mancozeb and dinocap at 15 days interval starting at 75 days of crop age.

An extensive survey was under taken during rabi 2004-2006 in major chickpea growing districts of Jammu division and it was revealed that the wilt disease was prevalent in all the locations (*Andrabi et a*l., 2008) and the incidence varied from 7.92 to 78.50 per cent thereby indicating the seriousness of problem. The samples of wilted plants collected from different locations revealed the association of *Fusarium oxysporum Fusarium solani* and *Rhizoctonia solani* with the wilted plants.

Integrated management of root rot and wilt diseases of French beans carried out by Dar *et al*. (2008) concluded with the recommendations on the basis of field experiments that FYM application @ 20 t ha^{-1-} and the seed treatment with myclobutanil 10 WP @ 0.1% or captan 50 WP + carbendazim 50 WP (1:1) @ 0.25% or *Trichoderma viride* (1 x 10^8 spores ml^{-1}). Fungicidal management of angular leaf spot (*Phacoisariopsis griscola*) of French beans in the form of seed treatment and foliar spray out (Sagar *et al*., 2008) revealed that seed treatment with carbendazim + foliar spray with carbendazim and seed treatment with myclobutanil + foliar spray with carbendazim will most effective reducing the per cent disease incidence to 35% and severity to 11.7%, respectively compared to 50% disease severity recorded in check.

Distribution and management of anthracnose of french bean caused by *Colletritrichum lindemuthianum* (Ambardar & Singh 2009) was investigated. Jaswan area of Jammu recorded the highest disease incidence of 53.9% disease severity of 7.0% followed by other areas. Seed treatment with benlate followed by foliar sprays with copper oxychloride give 71.08% decrease in disease over control with average pod yield of 166 kg/ha. However, maximum disease control of 77.05% and 75.04% over control with pod yield of 11230 kg/ha in treatments with benlate or bavastin followed by foliar spray of dithane M-45, respectively. CH-829 and commonly grown cultivar contender was found susceptible to the disease when 57 lines were evaluated in field.

CONCLUSION AND FUTURE THRUSTS

Pulse crops are predominantly grown in the developing countries and to cut down the ravages caused by diseases the farmers with linked resources need effective and low cost protection technology, which is only possible through reliable integrated diseases management systems. The information generated on the management practices for individual pulse diseases, need to be brought together and tested to develop IDM modules for specific locations to encounter multiple diseases. For a systematic approach to develop long term and sustainable IDM systems the foremost pre-requisite will be mapping of major diseases of pulses in respect of their occurrence and severity in the different agro-climatic regions of J&K state. Detailed disease distribution maps

based on precise surveys need to be prepared. This will enable to develop need based strategy for resistance breeding. The ongoing programme should be further vigorously pursued to identify stable and broad based multiple disease resistance sources and subsequent utilization in developing high yielding cultivars.

Approaches for IDM may be possible with the use of chemicals, resistant varieties, biological agents with modified cultural practices which may help in controlling the disease to some extent. Considering the diversity in pathogen and varied agro-climatic conditions influencing the disease, only single practice may not achieve the desired goal. Therefore, it would be worth while to integrate available compatible control practices to develop viable and economic integrated management strategies. Biotechnology innovations vis-à-vis genetic engineering offer a additional compliment to integrated disease management system to bridge the gap. The major thrust areas where the genetic engineering could contribute are: Developing transformed genotypes with specific pyramiding resistance and genes for adversity resistance. Evolving super strains of antagonists with high survival, root colonization production and wide spectrum antifungal compound production. Further, a joint venture with breeders, agronomists and biotechnologists can frame programme. Active involvement of farmers at all levels during the evaluation of newly designed IDM systems for its components is perhaps the most important factor that will ultimately stimulate the acquisition and use of technological information.

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A CASE STUDY IN VALERIANA JATAMANSI: AN IMPORTANT MEDICINAL PLANT OF KASHMIR HIMALAYA

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ABSTRACT

Himalaya is credited all over the world as a treasure of medicinal plants. Among these medicinal plants *Valeriana jatamansi* (Valerianaceae) have tremendous medicinal importance. Large-scale exploitation, biotic interferences and increasing demand for *Valeriana jatamansi* has threatened the very existence of the species. Conservation of the species has become need of the hour. Cultivation at large scale and development of elementary agro-techniques at lower altitudes under *ex-situ* conditions can prove viable in terms of economy and conservation.

Key words: *Valeriana jatamansi*, conservation, threatened

INTRODUCTION

India is recognized one of the mega biodiversity countries of the world and nurtures enormous plant diversity. However, this plant wealth is eroding at a fast pace due to habitat loss, fragmentation, over-exploitation, invasion of exotics, pollution and climate change. The biosphere has lost some valuable species and many more are threatened. According to estimates tropical forests alone are losing one species per day. The erosion of species richness is going to erode the valuable genomes, genes, ecosystem balance, ecosystem stability and a host of other characteristics which are hard to retrieve back. The anthropogenic interferences have deflected the natural directions, posing threat and thirst to the charming ecosystems. The population explosion and economic development, the world over has been the basic and fundamental reason for the depletion of natural resources. Growing awareness of the importance of plant diversity and rapid decline of these valuable plants, have given an unprecedented impetus for their monitoring and conservation (Victor, 2010).Any conservation approach has to be based on in-depth study of plant reproductive biology, as failure of reproductive processes to cope with the environmental changes is one of the fundamental reason for species loss and various reproductive characteristics such as seed dispersal, germination capacity, survival rate of seedlings and adults, age at flowering, reproductive life span and number of flowers and seeds refer to set of responses that allow a species to adapt to a particular environment (Moza and Bhatnagar, 2007). To develop a suitable prescription and

panacea, understanding of reproductive biology, seed biology and breeding behaviour is regarded to be of nuclear importance as well as the central element (Wafai and Nawchoo, 2001). *Valeriana jatamansi* Jones Syn. *Valeriana wallichi* (Bennet, 1987), popularly known as Indian valerian (English), Mushkibala (Kashmiri), Sughanthdhawal or Tagar (Sanskrit), (Raina and Srivastava, 1992). The species is being labeled as critically endangered due to over-exploitation of rhizomes for its medicinal value, habitat degradation and other biotic interferences in its distribution ranges. If left as such and exploited at the same rate, in near future, the species will disappear forever. Thus, convention on international trade on endangered species notified *Valeriana jatamansi* in its schedule for conservation. Keeping in view the immense medicinal importance and critically endangered status of *Valeriana jatamansi* it becomes necessary to study various asexual and sexual constraints if any, which in turn will prove to be helpful in planning the conservation strategies.

MATERIAL AND METHODS

During the present study various methods and scientific approaches were carried out in the field, laboratory and in natural habitats to understand the reproductive biology of *Valeriana jatamansi.* An extensive exploration of different Kashmir Himalayan habitats was carried out to identify specific areas across different geological conditions covering a wide range of habitats. Among various populations three sites were selected for further studies on the basis of following criteria:

- Accessibility of the site
- Habitat structure.
- Plant density

The salient features of the selected sites are depicted in Table 1.

Various populations were analyzed for plant structure, number of shoots per plant, rhizome shape and dimensions, plant height, leaf number and dimensions, flower structure and dimensions, structure of sex organs and seed size and number.

RESULTS

Valeriana jatamansi Jones (Valerianaceae) is perennial, critically endangered medicinal herb distributed in sub-temperate to temperate regions at an altitude gradient of 1200-3000m asl. It is commonly known as Mushkibala (Kashmiri), Tagar (Sanskrit), Indian Valerian (English) and Suganthdhawal (Tamil). Owing to its immense medicinal properties, over-exploitation of rhizome and roots for medicinal use and consequent degradation of natural habitats are major threats which the herb at present is facing. Since the species is categorized as critically endangered, it necessitates that *in situ* as well as *ex situ* conservation strategies.

During the present investigation the species was found sporadically distributed in the mountain ranges of Kashmir Himalayas confined to sub-temperate and temperate regions, thriving best in moist shady slopes, rocky slopes, land slide areas ranging in an altitude of 1200-3000m asl. The species was mainly found in Gulmarg, Ferozpora,

Yusmarg, Duksum, Sonamarg, Phalgam, Naranag and Dara. This species is a tufted, hairy herbaceous perennial, gynodiecious herb with hermaphrodite plants ranging from 13.0-37.70 cm in height

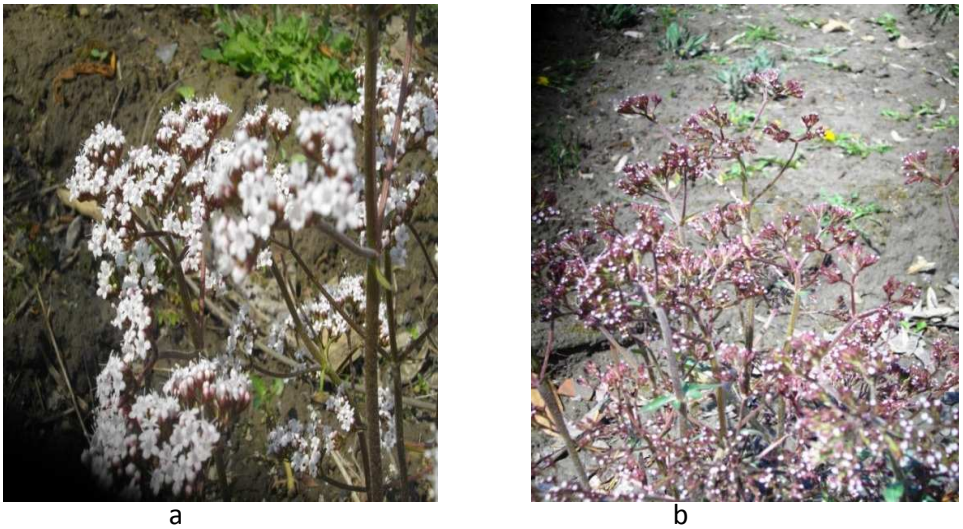
Table. 1 Salient features of some selected sites for studies on *Valeriana jatamansi*

Habitat character	Population		
	Gulmarg	**Ferozpora**	**KUBG***
Soil type	Humus rich	Humus rich	Sandy loam
Altitude (asl)	2650m	2150 m	1595m
Slope	Moderate to steep	Moderate to steep	Moderate
Forest range	Jehlum valley forest division	Jehlum valley forest division	-
Latitude/longitude	34º 04´/N 74º 20´/E	34º 04´/N 74º18´/E	34º 30´/N 75º 30´/E
Direction with reference to Srinagar	North west	North west	-
Habitat	Shady moist slopes	Shady rocky slopes	Open, plain with partial shade
Threat factor	Grazing, extraction, Habitat degradation and fragmentation	Grazing, extraction, Habitat degradation and fragmentation	-

KUBG- Kashmir University Botanical Garden (Transplant site)

and female plants found usually dwarf than hermaphrodite with heights from 10.90-29.50cm. The plant is characterized by thick horizontal rhizome with diameter ranging from 2.0-4.40cm with 10-37 roots per stock. Basal radical leaves are long stalked, deeply cordate -ovate, usually toothed or sinuate up to 3.20-8.30cm long and 2.40-7.50cm broad. Cauline leaves are only a few, much smaller, entire or sometimes pinnate of 1.90-2.70cm in length and 1.60-2.30cm in breadth. Flowers are white or tinged with pink in terminal corymbs with 8-13 female flowers per inflorescence and 8-14 hermaphrodite flowers per inflorescence which are larger and broader than female flowers and are ranging from 0.30-0.40cm across. Calyx is represented by inwardly curved ring which opens into plumose pappus at fruit setting stage. However, corolla is five lobed with rotate, white or pinkish depending on the availability of light. Gynoecium is tricarpellary

syncarpous. ovary seemingly unilocular with single ovule, ovary inferior and seed is one seeded achene (Fig. 1).



a b

Fig.1. ***Valeriana jatamansi:*** **(a) hermaphrodite plant in full bloom (b) female plant in flowering phase**

The seeds of *Valeriana jatamansi* usually over-winter in resting phase, exhibiting physiological dormancy. However, few seeds as and when get dispersed by parachute mechanism at relatively immature stage do germinate immediately subjected to the availability of micro site. The seedlings of such seeds hardly survive in nature because they have to face the onslaught of chill in winter. With the onset of favourable conditions (March-April) the least percentage of dormant seeds starts to germinate accounting for meager addition to the population in terms of new recruitments. The *in vivo* seed germination was worked out in KUBG (Kashmir University Botanical Garden) to see how seeds of *Valeriana jatamansi* behave to different habitat conditions and to successfully investigate the effect of open conditions and dappled or partial shade on germination of seeds in natural soils. It was observed that under dappled shade the %age seed germination was remarkably on the higher side (84.7%) as against the open sun conditions wherein only 48.73% germination was registered (Fig.2).

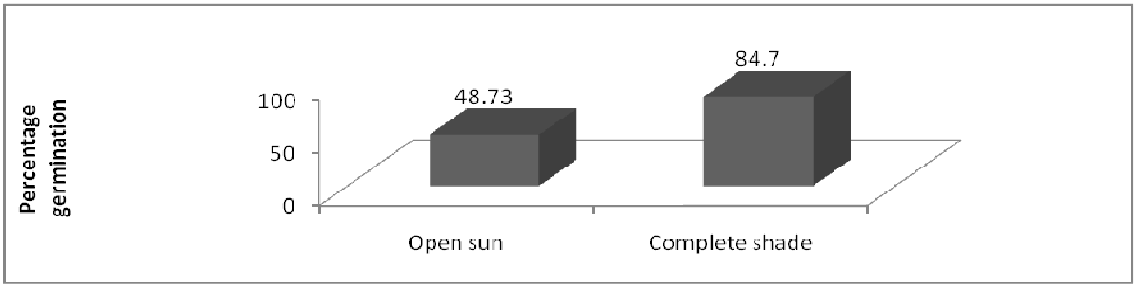


Fig. 2. Depicting comparative seed germination under two different condition

In vivo propagation studies reveal that rhizome cuttings of this plant (4-8 per plant) respond well to different treatments with IAA (1mM) and IBA (1mM). These chemicals were found to be most effective in increasing %age rooting and %age shooting with successful regeneration of each cutting into a new plant (Fig.3).

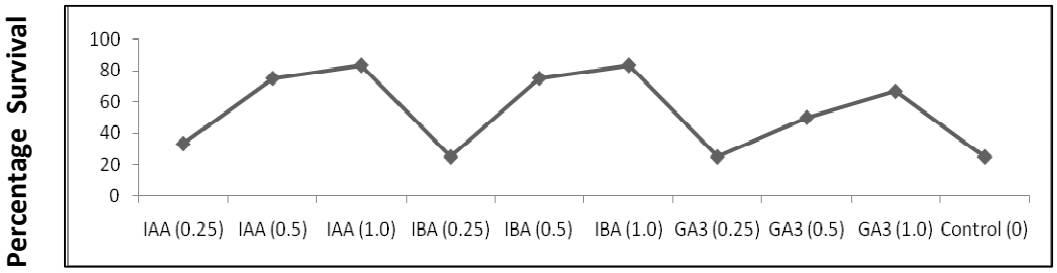


Fig. 3. Showing effect of different treatments on percentage survival of *Valeriana jatamansi*

DISCUSSION

A variety of approaches both *in situ* and *ex situ*, have been proposed and implemented for conservation of plant resources but any conservation approach has to be based on in-depth study of plant reproductive biology. Reproductive characteristics such as seed dispersal, germination capacity, survival rate of seedlings and adults, age of flowering, reproductive life span and number of flowers and seeds refer to a set of responses that allow a species to adapt to a particular environment. This species was found sporadically distributed over various sites of Kashmir Himalayas which include Shajnar, Dara, Harwan, Gulmarg, Yusmarg, Ferozpur, Sonamarg and Pahalgam (Naqashi and Dar, 1982-1986). These sites experience severe climatic conditions (low temperate, extreme variability in rainfall, fast winds, frequent clouds and high cosmic fallout etc.) and are too inaccessible. This taxon has a greater endurance to extreme environments which are ecologically specific and unique in terms of habit, altitude, plant associations, edaphic conditions. Due to high demand of its rootstock, it is being extracted from wild sources that led to extinction of this precious species from its natural habitats. The seeds of *Valeriana jatamansi* usually over-winter in resting phase, exhibiting physiological non-deep dormancy. However, few seeds as and when get dispersed by parachute mechanism at relatively immature stage do germinate immediately subjected to the availability of favourable environment. The seedlings of such seeds hardly survive in nature because they have to face the onslaught of chill in winter. With the onset of favourable conditions (March-April) the least %age of dormant seeds starts to germinate accounting for meager addition to the population in terms of new recruitments.

In order to overcome this bottleneck, the species has established an efficient method of vegetative propagation. The vegetative reproduction is accomplished through the

underground perenating buds borne on the underground rhizome. However, in next growing season the fresh rhizomes usually produces 5-8 perenating buds, which develop into leafy shoots. Thus *Valeriana jatamansi* is adapted both to vegetative as well as sexual reproduction with the former providing stability to the genotype at a particular site and the later contributing to generation of variability through sexual recombination of genes. As the species perenniates through rhizomes which give rise to numerous flowering shoots in each flowering season, this feature not only helps the plant to establish at a location but also ensures perpetuation even in absence of seed setting (Dhami and Mahindru, 1998). However, vegetative propagules have some advantage over the seeds in that they have a tremendous head start development and growth, often mature earlier and may have better juvenile survivorship and less mortality (Amor, 1974; Abrahamson, 1980). The difference even though marginal clearly demonstrate that rhizome cuttings with an apical shoot have the capability to regenerate into new plants under *ex-situ* conditions. Utilizing this cost effective method of propagation, the species can be multiplied in lesser time with good survival rates. Similar kind of trend has been earlier been reported by Nautiyal *et al.* (2001)

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PHENOTYPIC DIVERSITY IN PLUM GERMPLASM UNDER CULTIVATION IN KASHMIR VALLEY

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ABSTRACT

The plums (*Prunus domestica* L. and *P. salicina* Lindl.) under cultivation in Kashmir valley exhibit remarkable diversity in their tree, foliar, floral and fruit characteristics. Thirteen cultivars viz. Dach Aer, Wangan Aer, Sabni Aer, Amb Aer, Chogander, Silver, Santa Rosa, Damson Zarad, Damson Surkh, Gurdalu, Sabza, Jungli Aer, and Rehman Bagwani presently growing in Kashmir have been evaluated for their phenotypic variability at inter-cultivaral level. Analysis and assessment of this diversity shall provide a strong edifice on which a breeding programme for their improvement can be launched.

Key words: Plums, cultivars, phenotypic diversity, germplasm

INTRODUCTION

Belonging to section *Prunophora*, subgenus *Prunus,* in genus *Prunus* L. (subfamily Prunoideae of Rosaceae) plums represent an important fruit crop of the temperate world. China, Serbia, USA, Romania, Turkey, Spain, Italy, Bosnia, France, Ukraine, Germany, and Chily are the top plum producing countries of the world. China with an annual plum production of 5,373,001 tons tops the list by contributing more than 50% of the crop at world level (FAO, 2009).

Plums are the most polymorphic of all the stone fruits and include a large range of types varying in habit, foliar, floral and fruit characteristics. Based on the centre of origin they are broadly grouped as European plum(*P. domestica* L.), Damson plum (*P.insititia*), Cherry plum (*P. cerasifera*), Japanese plum (*P. salicina*), and American Plum (*P. americana*) having Europe, West Asia, West and central Asia, China, and North America as their respective centres of origin (Watkins, 1976).

Plums grown in the Himalayan region mostly belong to *P. domestica* or *P. salicina*. In Kashmir valley, which represents the major plum producing area of the country, more than 1000 hectares of land are under cultivation of this fruit. The major plum growing areas are Sopore, Pattan, Narbal, Tangmarg, Zakura, Habak, Nishat, Tailbal, Pampore, Pulwama, Shopian and Bagat-e-kannipora. Locally called "Aer", about 31 varieties are reported to be cultivated here (Anon. 1967-68, 1971-72) and belong to *P. domestica, P. salicina* or represent their hybrids. Some popular cultivars are Santa Rosa, Rehman Bagwani, Silver, Chogander, Amb Aer, Wangan Aer, Sabne Aer, Damson Zarad, Damson Surkh, Dach Aer, Jungli Aer,

Gurdalu and Sabza. Being highly perishable, the fruit is consumed fresh, canned and made into jams, rarely dried or cooked when ripe.

The plum germplasm in Kashmir is replete with diversity which has accumulated partly through hybridization and seed based propagation, bud mutation and selection and partly through continuous introduction of newer cultivars from the western world. Existence of tremendous genetic diversity in this fruit promises a strong edifice on which an ambitious breeding programme can be launched. But various kinds of stresses such as selective and yield based propagation on the one hand and ruthless felling of the trees for baker's fuel on the other have brought some of the prized cultivars to the brink of extinction. It is need of the hour to launch a multidimensional programme not only to salvage this important horticultural resource but also to improve and upgrade it.

MATERIAL AND METHODS

Thirteen cultivars of plum belonging to *P. domestica* L. and *P. salicina* Lindl. (including some which could not be identified at species level) growing in different orchards of the valley constituted the material for the present study (Table 1). One to five trees of each cultivar were selected at random and selected for tree, foliar, floral and fruit morphology. Tree height has been measured by a measuring tape and shape of the crown has been categorized into erect, semi-errect and spreading.

The leaf size and area has been worked out by marking the boundary of the leaf on the graph paper and counting the total number of squares involved. Celluloid replica method has been employed for working out the stomatal density. A thin film of Quick Fix adhesive was gently spread over some area of both the leaf surfaces. After about five minutes the replica was scraped and mounted in water on a glass slide and the number of stomata per field of microscope counted at 400x magnification.

Area of the microscopic field (πr^2) was measured by ocular and stage micrometer. Guard cell length has been determined at 400x magnification with the help of an ocular and stage micrometer after staining the epidermal peeling in 1% safranin.

The fruits were scanned for shape, size, colour of the skin, taste of the flesh (subjective personal experience), and weight of the fruit, stone and kernel. Nomenclature by Beach (1905) and Taylor (1936) for the fruit shape of apples has been adopted Definitions of some of the uncommon terms pertaining to fruit shape are as under:

Oblate: diameter of the fruit more than its length;

Ovoid: fruit intermediate in shape between spherical and conical;

Lopsided: one side of the fruit larger and better developed than the other;

Symmetrical: sides of the fruit equally developed.

Table 1. Plum Cultivars Presently Investigated

Species	Cultivar	Source
Prunus domestica L.	Dach Aer	Horticulture Nursery, New Thed, Harwan, Srinagar
	Wangan Aer	Simon Orchards, Habak, Srinagar
	Sabni Aer	Shahdad Orchards, Habak, Srinagar
P. salicina Lindl.	Amb Aer	Horticulture Nursery, Zakura Srinagar
	Silver	Simon Orchards, Habak, Srinagar
	Chogander	Horticulture Nursery, Zakura Srinagar
	Santa Rosa	Horticulture Nursery, Zakura Srinagar
Unidentified cultivars	Gurdalu	Shahdad Orchards, Habak, Srinagar
	Damson Zarad	Shahdad Orchards, Habak, Srinagar
	Damson Surkh	Wani Orchards, Naseem Bagh, Srinagar
	Jungli Aer	Shahdad Orchards, Habak, Srinagar
	Rehmani Bagwani	Horticulture Nursery, Zakura Srinagar
	Sabza	Shahdad Orchards, Habak, Srinagar

Cruden's (1977) method has been employed for making the pollen count per anther. Pollen diameter has been worked out using ocular and stage micrometer.

Swanson and Sohmer's (1976) method has been followed for working out pollen fertility. Anthers were squashed in 2% propionocarmine. Plump, healthy and well stained pollen have been scored as viable.

RESULTS

Thirteen cultivars belonging to *P. domestica* L. and *P. salicina* Lindl. and some which could not be identified at species level were analyzed for their phenotypic characters. The cultivars have been studied for their tree, foliar, floral and fruit characteristics (Table 2-6; Fig.1.) The details are given below:

P. domestica L. (European plum): The inflorescence, which is fascicled raceme in older branches and simple raceme in younger branches, is composed of both simple (giving one flower only) and compound (giving more than one flower) buds in Dach

Aer and Wangan Aer while in Sabni Aer only simple buds are present.

Table 2. Crown and leaf characters of plum cultivars in Kashmir valley

Species	Cultivar	Crown	Leaf		
			size	abaxial surface	texture
Prunus domestica L.	Dach Aer	semi-errect	bigger*	pubescent	thick
	Wangan Aer	errect	bigger	pubescent	thick
	Sabni Aer	spreading	bigger	pubescent	thick
P. salicina Lindl.	Amb Aer	errect	smaller	glabrous	thin
	Chogander	spreading	smaller	glabrous	thin
	Silver	semi-errect	bigger	glabrous	thin
	Santa Rosa	errect	bigger	glabrous	thin
Cultivars not identified at species level					
	Damson Zarad	errect	smaller	glabrous	thin
	Damson Surkh	errect	smaller	glabrous	thin
	Gurdalu	spreading	smaller	glabrous	thin
	Sabza	spreading	smaller	glabrous	thin
	Jungli	errect	smaller	glabrous	thin
	Rehman Bagwani	spreading	smaller	glabrous	thin

*Bigger leaves: > 20 cm^2 area; smaller leaves: < 20cm^2 area

Table 3. Foliar features of plum cultivars under cultivation in Kashmir valley

Leaf characteristics	Dach Aer	Wangan Aer	Sabni Aer	Amb Aer	Chogander	Silver	Santa Rosa	Damson Zarad	Damson Surkh	Gurdalu	Jungli Aer	Rehman Bagwani	Sabza
Qualitative													
Shape	broadly obovate	elliptic	elliptic	longly obovate	obovate	oblanceolate	obovate or elliptic	elliptic	elliptic	elliptic	elliptic	elliptic or obovate	elliptic
Leaf base	obtuse	obtuse or cuneate	cuneate	cuneate	cuneate	cuneate	cuneate	cuneate	cuneate	obtuse	cuneate	obtuse or cuneate	cuneate
Leaf apex	apiculate	acute to acuminate	acute	acuminate	acuminate	acuminate	acuminate	acuminate	acuminate	acuminate	acute	acute or acuminate	acuminate
Dentations	crenate	crenate	crenate	serrulate	serrulate	crenate	crenate	serrulate	serrulate	serrulate	crenate	serrulate	serrulate
Quantitative *													
Leaf length (cm)	8.88±0.41	8.27±0.42	9.41±0.53	8.16±0.54	6.26±0.38	9.35±0.55	10.54±0.62	6.30±0.41	6.6±0.41	6.18±0.37	6.93±0.19	6.80±0.46	5.76±0.37
Leaf breadth (cm)	6.64±0.31	4.86±0.28	5.3±0.3	2.97±0.2	2.6±0.15	4.04±0.26	5.23±0.38	2.89±0.23	3.09±0.29	3.62±0.22	3.78±0.15	3.65±0.38	3.09±0.23
Length/breadth ratio	1.33	1.7	1.77	2.74	2.4	2.31	2.01	2.17	2.13	1.7	1.83	1.86	1.86
Leaf area (cm^2)	41.45±3.27	28.48±3.15	34.66±3.8	5.58±1.86	11.87±1.3	21.85±2.3	34.56±4.47	14.25±1.94	14.34±1.94	15.61±1.85	17.51±1.16	17.74±2.78	11.59±1.71
Petiole length (cm)	1.55±0.01	1.71±0.1	1.94±0.17	1.68±0.13	0.97±0.05	1.75±0.19	1.42±0.67	1.45±0.18	1.42±0.12	1.19±0.09	1.60±0.05	1.45±0.08	1.32±0.15
Stomatal density/mm^2	440.66±0.7	270.89±0.43	270.07±0.45	730.9±1.25	520.48±0.55	830.17±1.41	570.01±1.04	700.03±0.83	690.85±0.83	380.32±0.89	270.13±0.83	570.45±0.66	350.56±0.57
Guard cell length (μm)	20.2±0.29	27.38±0.7	28.32±0.32	20.2±0.25	19.32±0.17	19.11±0.2	19.35±0.25	18.76±0.17	19.13±0.19	20.2±0.29	23.01±0.42	18.55±0.19	20.2±0.29

*Quantitative characters: Mean ±S.E; sample size for each parameter= 50

Table 4. Quantitative floral and pollen characters of plum cultivars under cultivation in Kashmir Valley

Floral and pollen features	Dach Aer	Wangan Aer	Sabni Aer	Amb Aer	Chogander	Silver	Santa Rosa	Damson Zarad	Damson Surkh	Gurdalu	Jungli Aer	Rehman Bagwani	Sabza
Floral diameter (cm)	2.05±0.05*	3.13±0.03	3.08±0.06	2.0±0.04	1.83±0.05	1.85±0.04	1.8±0.04	1.88±0.04	2.35±0.02	2.15±0.05	2.8±0.04	2.12±0.04	2.15±0.03
Petal length (cm)	1.02±0.01	1.23±0.01	1.44±0.01	1.12±0.03	0.81±0.02	0.97±0.02	0.95±0.01	0.97±0.01	1.06±0.01	1.05±0.02	1.23±0.01	1.06±0.02	1.17±0.01
Petal breadth (cm)	0.82±0.02	1.23±0.02	1.17±0.01	0.79±0.02	0.74±0.01	0.66±0.13	0.79±0.02	0.65±0.01	0.86±0.02	0.8±0.01	0.95±0.01	0.87±0.01	0.79±0.02
Filament length (cm)	0.79±0.07	0.77±0.00	0.86±0.01	0.72±0.01	0.63±0.00	0.52±0.00	0.83±0.01	0.55±0.01	0.72±0.00	0.53±0.01	0.38±0.00	0.82±0.01	0.62±0.00
Style length (cm)	0.89±0.01	1.18±0.02	1.28±0.02	1.09±0.01	1.11±0.02	0.65±0.01	0.81±0.03	0.78±0.01	0.85±0.01	0.83±0.01	1.1±0.02	0.97±0.02	0.93±0.02
Pedicel length (cm)	0.87±0.05	1.24±0.02	1.29±0.03	1.27±0.04	1.04±0.02	0.09±0.03	1.8±0.07	0.84±0.01	1.05±0.01	1.00±0.03	1.14±0.07	1.15±0.03	1.47±0.02
Pollen no. per anther	984±3.12	889±2.37	973±3.09	1136±2.46	NA	419±2.01	775±2.51	497±1.67	689±1.94	1727±2.53	1017±2.16	762±1.86	1095±2.71
Pollen diameter (µm)	46.73±0.72	47.88±0.73	44.4±0.79	33.86±0.4	NA	21.6±0.05	39.08±1.26	34.64±0.26	30.98±1.24	43.2±0.52	32.1±0.76	37.46±0.96	43.88±0.29
Pollen viability (%)	46.74	40.41	49.19	91.41	NA	00.00	45.23	79.41	43.31	64.25	00.00	58.5	36.9

* Mean ±S.E; sample size for each parameter= 50

Table 5. Diversity in fruit, stone and kernel quantitative characters of plum cultivars under cultivation in Kashmir Valley

Fruit characters	Dach Aer	Wangan Aer	Sabni Aer	Amb Aer	Chogander	Silver	Santa Rosa	Damson Zarad	Damson Surkh	Gurdalu	Jungli Aer	Rehman Bagwani	Sabza
(a)Fruit													
Weight (gm)	11.77±0.30	73.18±1.18	21.28±2.37	60.36±0.04	24.0±0.94	51.48±1.76	43.89±2.69	NA	16.31±0.33	5.49±0.15	23.49±0.48	14.81±0.37	11.51±0.43
Size (cm)													
Length	2.45±0.02	5.7±0.04	3.14±0.03	4.72±0.06	3.3±0.05	4.23±0.02	3.8±0.07	NA	3.05±0.02	2.05±0.01	3.39±0.02	2.85±0.02	2.39±0.03
Breadth	2.58±0.02	4.4±0.03	3.06±0.03	4.14±0.04	3.29±0.04	4.14±0.04	3.8±0.08	NA	2.79±0.01	2.04±0.01	3.19±0.02	2.82±0.02	2.58±0.03
Thickness	2.52±0.02	4.16±0.03	3.04±0.03	4.06±0.01	3.31±0.04	4.06±0.04	3.76±0.07	NA	2.92±0.02	1.96±0.01	3.16±0.02	2.73±0.02	2.64±0.03
(b)Stone													
Weight (gm)	1.02±0.02	2.54±0.04	1.44±0.02	1.46±0.03	0.79±0.02	1.39±0.04	1.26±0.03	NA	0.78±0.02	0.31±0.00	1.22±0.02	0.63±0.02	0.52±0.01
Size (cm)													
Length	1.69±0.01	2.62±0.02	2.03±0.01	2.47±0.02	1.82±0.02	2.4±0.02	2.15±0.02	NA	1.76±0.01	1.47±0.02	2.07±0.01	1.64±0.01	1.47±0.00
Breadth	1.31±0.01	1.9±0.01	1.44±0.02	1.56±0.01	1.31±0.01	1.50±0.01	1.44±0.03	NA	1.27±0.01	0.83±0.01	1.31±0.01	1.2±0.01	1.19±0.00
Thickness	0.81±0.00	0.99±0.00	0.89±0.00	0.88±0.01	0.67±0.00	0.90±0.01	0.89±0.01	NA	0.73±0.00	0.58±0.00	0.58±0.00	0.66±0.00	0.73±0.00
(c)Kernel													
Weight(gm)	0.2±0.00	0.5±0.01	0.23±0.00	0.18±0.00	0.19±0.00	0.33±0.00	0.09±0.12	NA	0.19±0.00	0.09±0.00	0.22±0.00	0.2±0.00	0.16±0.00
Size(cm)													
Length	1.18±0.01	1.67±0.05	1.37±0.01	1.36±0.01	1.21±0.01	1.42±0.01	1.21±0.02	NA	1.18±0.02	0.97±0.01	1.36±0.01	1.18±0.01	1.02±0.01
Breadth	0.73±0.00	0.99±0.00	0.79±0.00	0.79±0.00	0.75±0.01	0.79±0.01	0.68±0.01	NA	0.75±0.01	0.53±0.00	0.79±0.00	0.71±0.01	0.71±0.01
Thickness	0.46±0.00	0.45±0.01	0.46±0.00	0.42±0.00	0.37±0.02	0.52±0.00	0.32±0.02	NA	0.37±0.00	0.37±0.00	0.37±0.00	0.41±0.00	0.41±0.00

Figures represent Mean ±S.E; sample size for each parameter= 50

Table 6. Fruit characters of plum cultivars presently studied

Cultivar	Shape and nature of the fruit	Colour and nature of the skin	Colour and nature of the flesh
Dach Aer	spherical, shallowly sutured	bluish purple, glaucous, highly acidic	green, acidic*
Wangan Aer	pyriform, deeply sutured	intense carmine on the exposed side and light carmine on the shaded side, glaucous, acidic	carminish-yellow, crisp, sub-acidic
Sabni Aer	spherical, shallowly sutured	light green or yellowish, glaucous, acidic	light green or yellowish, acidic
Amb Aer	mangiform, deeply sutured	yellow, blushed with light carmine on the exposed side, glaucous, acidic	light yellow, acidic
Chogander	spherical, shallowly sutured	light-green or yellowish, glaucous, acidic	light-green or light-yellow, acidic
Silver	cordate, deeply sutured	light carmine, glaucous, acidic	light yellow, acidic
Santa Rosa	spherical or ovate, deeply sutured	intense carmine on the exposed side and light carmine on the shaded side, glaucous, acidic	carmine on the exposed side and light carmine on the shaded side, sub-acidic
Damson Zarad	cordate, sutureless	light yellow, glaucous, acidic	light yellow, sub-acidic
Damson Surkh	cordate, sutureless	intense carmine, glaucous, acidic	intense carmine, sub-acidic
Gurdalu	globose, suture shallowly visible in a thin line	green, shiny, acidic	green, juicy, acidic
Jungli Aer	spherical, shallowly sutured	light yellow, glaucous, acidic	light yellow, sub-acidic
Sabza	globose or oblate, shallowly sutured	green, shiny, acidic	green, acidic
Rehman Bagwani	cordate, shallowly sutured	light or intense carmine, glaucous, acidic	carminish yellow, subacidic

* Subjective personal experience

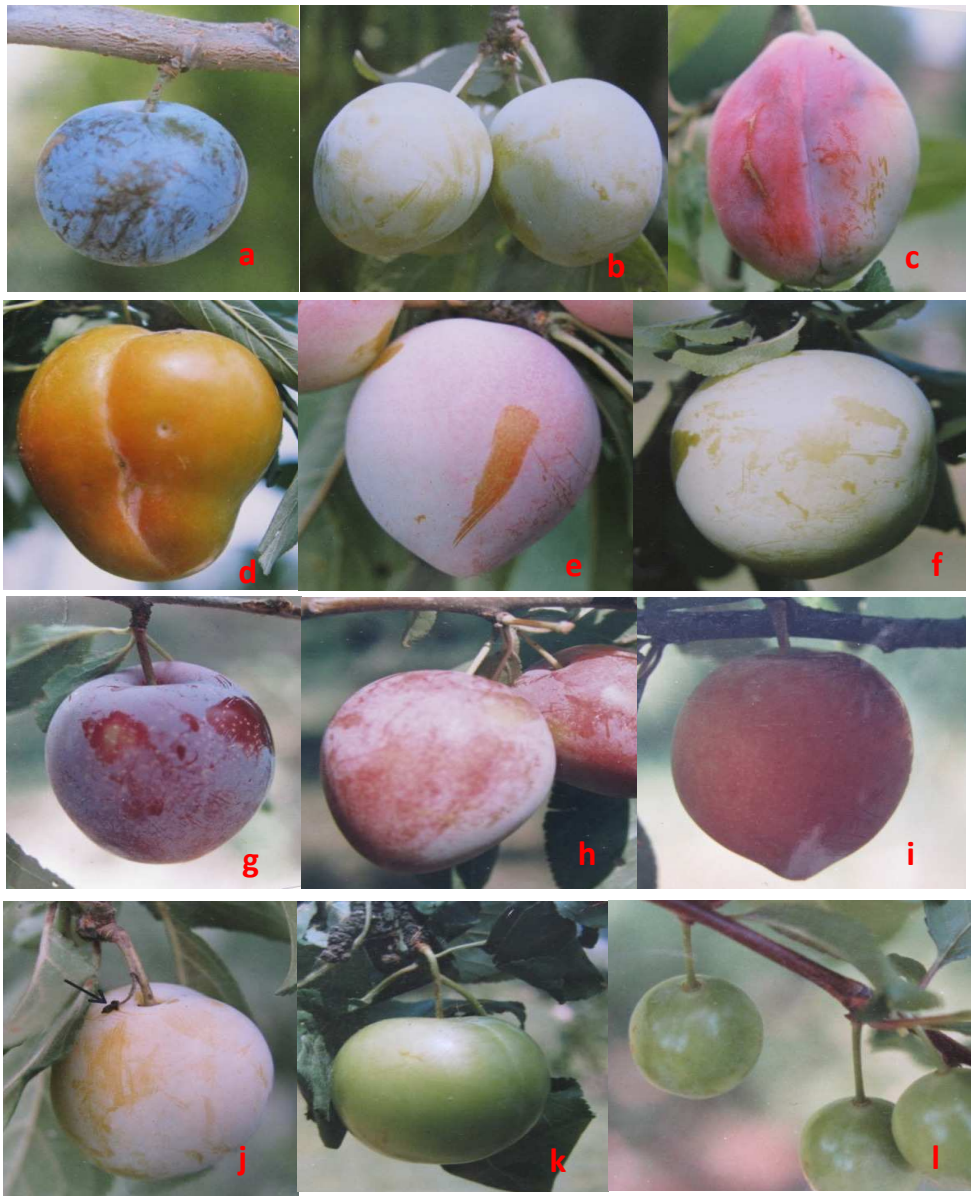

Fig.1. Plum fruits: **a**, Dach Aer; **b**, Sabni Aer; **c**, Wangan Aer; **d**, Amb Aer; **e**, Silver; **f**, Chogander; **g**, Santa Rosa; **h**, Damson Surkh; **i**, Rehman Bagwani; **j**, Jungli Aer; **k**, Sabza; **l**, Gurdalu

***P. salicina* Lindl. (Japanes e plum):** The inflorescence is composed of both simple and compound buds arranged in fascicled racemes on older branches and simple racemes on younger branches.

Unidentified cultivars: Six cultivars viz. Damson Zarad, Damson Surkh, Rehman Bagwani, Jungli Aer, Gurdalu, and Sabza, constituting this lot were studied for their morphological characters, both vegetative and reproductive (Tables 2-6, Fig 1h-l). The inflorescence is composed of both simple and compound buds in the first four cultivars

while in the last two i.e., Gurdalu and Sabza, it is composed of only simple buds.

DISCUSSION

Taxonomy & Local Nomenclature

The genus *Prunus* represents a renowned taxonomic complex and an assemblage of species exhibiting tremendous morphological diversity. Many workers viz. Rehder (1954), Knight (1969), and Zylka (1970) attributed this diversity to frequent hybridization within the subgenera and sections. Of any subgenus in the genus *Prunus* plums belonging to subgenus *Prunus* section *Prunophora* display the greatest genetic and morphological diversity and in the opinion of Watkins (1976) represent a link between the major subgenera that constitute the genus. Bailey (1919) remarks that "the flora of plums is very complex" and can be divided into eight groups each representing one or more species namely: Domestica or European plums (*P. domestica*), Myrobalam or Cherry-plums (*P. cerasifera*), Japanese plum (*P. salicina*), Apricot or Simon plums (*P. simonii*), American plums (*P. americana*), Wild Goose or Chickasaw plums (*P. hortulana*), Beach plums (*P. maritima*), and Pacific Coast native plums (*P. subcordata*).

The plums under cultivation in Kashmir are of varied types. Seven of the 13 cultivars presently studied belong to *P. domestica* and *P. salicina* and the remaining six could not be allocated to any species. Some of the unidentified cultivars resemble both *P. domestica* and *P. salicina* in certain foliar and fruit characters and, therefore seem to be of hybrid origin having one or both of these species as their putative parents. The details are presented in Table 7.

The cultivars presently studied are popularly known only by their local Kashmiri names which find exclusive usage even in their trade both within the local as well as the outside markets all over the country. On this basis one would be tempted to speculate that these cultivars might have originated in the valley's orchards. However, most of them have European names (Table 8), but being probably difficult to pronounce by the local populace and the orchardists got replaced over the years by Kashmiri epithets. On the contrary, a few cultivars (e.g., Rehman Bagwani, Dach Aer, Jungli Aer) have no European name and are known by local Kashmiri names only. Such cultivars may have originated in the valley's orchards from hybrid seed or as bud mutants which through selection over the years established as full-fledged marketable cultivars. The table indicates that majority of the local names assigned to these cultivars reflect the shape or colour of the fruit or the name of the orchardist from whose orchard they were recovered. Some of the local names, however, connote no varietal attribute, qualitative or quantitative, hence seem to have been arbitrarily assigned. For example perusal of literature reveals that Damson plums constitute a distinct group of plums under *P. domestica* complex and named *P. domestica* L. var. *insititia* (Bailey, 1919) and *P. domestica* L. subsp. *insititia* Schneid; Ghora and Pannigrahi, 1984). The distinguishing features of this group as enumerated by the above authors are shown in Table 9, but what is intriguing is that none of these two varieties exhibits any similarity with Damson plums described by Bailey (1919, 1949). This indicates that the local names damson Zarad and Damson Surkh are mere misnomers.

Table 7. Taxonomy of plums grown in Kashmir

Species	Cultivar (local name)	Distinguishing features
Prunus domestica L.	Dach Aer Wangan Aer	Leaves thick, large and pubescent, fruits of various shapes, sizes and colours viz., green, yellow, bluish-purple and red, shallowly sutured
	Sabni Aer	Fruit greenish or yellowish green, spherical, small or large, of high quality
P. salicina Lindl.	Amb Aer Chogander Silver Santa Rosa*	Leaves thin, long, smooth beneath, fruit round or tending to be pointed at apex, yellow or red, sutured.
Unidentified cultivars	Damson Zarad Damson Surkh	Leaves resemble *P. salicina* but fruits being sutureless doubts their allocation to this species
	Gurdalu Sabza	Fruit colour resembles *P. domestica* but not quality. They are intensely sour unlike *P. domestica* fruit. Leaves resemble those of *P. salicina* in being thin and glabrous beneath.
	Rehman Bagwani	Fruit shape resembles that of *P. salicina* and shallow suture that of *P. domestica*. Leaves resemble the former in being thin and glabrous beneath but differ from it in being shorter and broader and can easily be distinguished from those of the cultivars falling in *P. salicina*.
	Jungli Aer	In local dialect the term 'Jungli' points to the seedling origin of a cultivar. This cultivar has leaves of 'salicina' type and fruit of 'domestica' type.

*The cultivar is reported by some authors to be a complex hybrid between *P. salicina, P. simonii* and *P. americana*, with the 'salicina' characters predominating.

Table 8. Nomenclature of plum cultivars under cultivation in Kashmir Valley

Kashmiri name	European name (Annon. 1967-68)	Attributes connoted by Kashmiri name
Dach Aer*	--	The fruit resembles purple grapes in colour. In Kashmiri language "Dach" means grapes
Wangan Aer	Grand Duke	Fruit resembles brinjal in colour and shape. Brinjal in Kashmiri language is called "Wangun"
Sabni Aer	Reine claudede - Bavy	Fruit skin resembles in colour the locally prepared soap. The vernicular name of soap is "Saban"
Amb Aer	Wickson	Fruit mango-shaped. Locally mango is called "Amb"
Chogander	Satsuma	?
Silver	Burbank	The term "Silver" refers to whiteness. Unlike the other cultivars, the leaves of this cultivar have whitish bloom on the adaxial surface
Santa Rosa**	Santa Rosa	?
Damson Zarad	Cloth of the Gold	Fruit yellow. "Zarad" is the vernicular name of yellow colour
Damson Surkh	Reine claude Red	Fruit red. "Surkh" is the vernicular rendering of red colour
Gurdalu	Mirabella Precece	?
Sabza	Bryanston's Gage	Fruit skin green. "Sabz" in vernicular refers to green colour
Jungli Aer*	--	The term "Jungli" refers to seedling origin of the cultivar
Rehman Bagwani*	--	The name refers to the orchardist in whose orchard it was first found

*These cultivars have no foreign names.

** Santa Rosa is the most popular name of this cultivar. The State Department of Horticulture (Annon. 1976-68) has recorded a kashmiri name "Mishri Surkh" for this cultivar. The name is not in common use, hence doubtful.

PHENOTYPIC VARIABILITY

Qualitative characters: The crown is semi-errect in majority of the cultivars and erect or spreading in a few. The shape of the crown is specific to a cultivar and, therefore, seems to be genetically determined. The shape of the leaf, nature of dentations, presence or absence of pubescence on the leaf surfaces, and texture of the leaf vary a great deal from cultivar to cultivar and provide a very useful index for identification of different cultivars. Perusal of literature (Bailey, 1919; Ghora & Pannigrahi,1984) reveal that the plum taxonomists have frequently used foliar features to classify the plums into groups, varieties, subspecies and species. On the basis of the presence or absence of pubescence and texture of leaves the cultivars presently investigated can be classified into two distinct groups: (i) those having thicker leaves with pubescence on the abaxial leaf surface and (ii) those having thin leaves with glabrous leaf surfaces. The former comprise *P. domestica* and the latter *P. salicina*. Plums are highly diverse in their fruit characteristics and on this basis can be distinguished into cultivars. On the basis of taste of flesh and colour of skin, the 13 cultivars constituting the present sample can be subdivided into several groups as shown in Fig 2.

The shape of the fruit is so highly variable at intercultivaral level, every individual cultivar represents a unique genotype for this character and no discrete groups can be made.

Quantitative characters: The size and area of leaves are highly plastic in plums. The size ranges from 4.0 x 2.0 to 14.0 x 8.0 cm and the area from 5.31 to 63.85 cm^2. On the basis of leaf length, the cultivars presently investigated can be grouped as under:

(i) Long-leaved: Six cultivars namely, Dach Aer, Wangan Aer, Sabni Aer, Amb Aer, Silver and Santa Rosa, averaging in their leaf length from 8.16 to 10.84 cm, comprise this group.

Short-leaved: Seven cultivars namely Chogander, Gurdalu, Sabza, Jungli Aer, Rehman Bagwani, Damson Surkh and Damson Zarad, having their average leaf length less than 8.0 cm, comprise this group. The stomatal density and guard cell length in the presently studied sample vary a great deal from cultivar to cultivar and these differences are statistically significant ($p<0.001$). While the least stomatal density (270.07±0.45*/ mm^2) is characteristic of Wangan Aer, the highest values (830.17±1.41/mm^2) are found in cultivar Silver. Similarly the largest guard cells (28.32±0.32 µm*) are characteristic of Sabni Aer, the smallest are found in Rehmani Bagwani (18.55±0.91 µm). The quantitative characters of the fruit reveal that biggest fruits are characteristic of Wangan Aer, followed by Amb Aer, the smallest are found in Gurdalu. The present sample of cultivars exhibit great variability in their pollen yield, pollen size and pollen fertility. While Gurdalu produces an average of 1727±2.53 pollen per anther and ranks first in the list, Silver produces minimum number. As regards size, Wangan Aer produces the biggest pollen having an average diameter of 47.88±0.73 µm while smallest pollen with an average diameter of 30.08±1.24 µm. The highest pollen fertility is characteristic of Amb Aer followed by Damson Surkh, while cultivars such as Silver and Jungli Aer are male sterile producing only infertile and shriveled pollen. Because of their constant behaviour from year to year in this respect, it seems that male sterility in these cultivars is genetically predisposed. Earlier the phenomenon has been reported in several rosaceous fruits such as *Pyrus communis* (Crane, 1915), *Prunus persica* (Vitkoviskii and Ruben, 1974) and *Prunus avium* (Kaul, 1988).

*Mean±S.E

Table 9. Distinguishing features of Damson plums (P. domestica var. insititia; Bailey, 1919) compared with Damson plums cultivated in Kashmir valley.

Attribute	Damson plums (Bailey, 1919)	Damson Zarad & Damson Surkh cultivated in Kashmir
Leaf	Smaller, firmer in texture, thicker and pubescent beneath	Smaller, soft in texture, thin and glabrous beneath. Only mid rib pubescent.

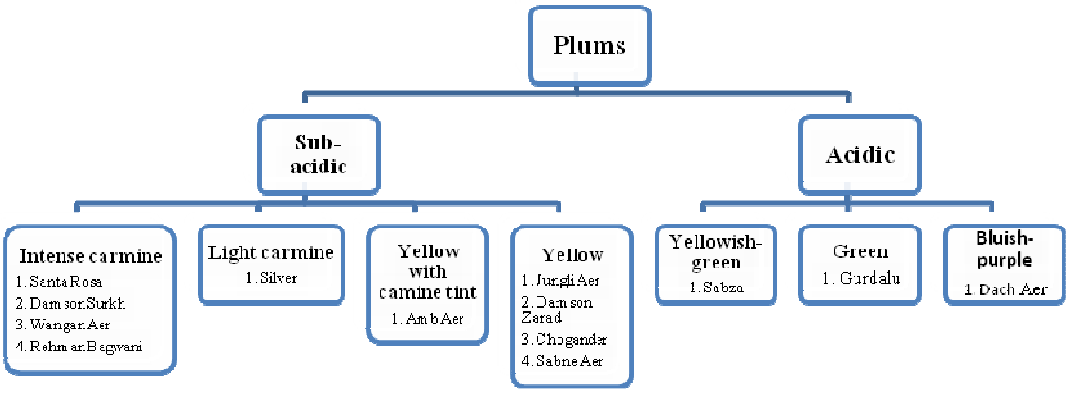

Fig.2. Classification of plum fruit on the basis of taste and skin colour

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FRAMEWORK OF MICRO WATERSHED MANAGEMENT PLANNING IN WATER SCARCE AREA OF DHABI VILLAGE IN SIWALIK FOOTHILLS OF KATHUA DISTRICT, JAMMU AND KASHMIR STATE

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ABSTRACT

The Siwalik foothill region, commonly known as Kandi belt in J&K, is spread in north-western states of India with an estimated area of 811 Km^2 located in the foothill zones of Siwalik of J&K State. Degraded catchments, undulating topography, erratic distribution of rainfall in space and time, high runoff with erosion, coarse texture etc. are some of the typical characteristics of this region, which makes it highly water scarce region. The water scarcity problem increases many fold during lean period stretching from April to June. The vision for Dhabi-Maltha Watershed management in Kandi belt is to ensure its transformation to sustainable landscape which maximizes the natural diversity and provides economic opportunities as well as ecological goods and services.

The present paper deals with the construction of water harvesting structure in Dhabi-Maltha area based on its topography, geology and hydro-geology. The paper also highlights the primary and secondary benefits which are likely to accrue to local population including enhanced availability of surface and sub-surface water, increased production systems, promotion of wildlife/ biodiversity, amelioration of ecology and consequent improvement in socio-economic status of people of area.

Key Words: Water management planning, kandi, water harvesting.

INTRODUCTION

Water is foundation of all biological life and equally fundamental for human life as it hydrates our body, grows our food, power our industry and nourishes our terrestrial and aquatic ecosystems (Birot and Garcia, 2011), thus, a very vital and valuable natural resource. Despite being richly endowed with vast natural water resources and a high precipitation rate, some areas at the foothills of North Western Himalayas ironically suffer from water scarcity, particularly during the pre-rainy season. Since mountains and hills form the natural catchments for rain water, hence strategies are required to be evolved in such areas to limit the surface run-off, enhance availability of rainwater, avert

floods, and reduce negative effects of soil erosion and siltation of structures downstream. Small- scale watershed management targeted at impounding and managing the surface water through its harvest can be conveniently used in water-scarce regions to ensure sufficient quantity of water for domestic, agriculture, livestock, industrial and competing usage during the lean season. Besides recharging the groundwater and promotion of sub-surface water availability, such ventures also provide additional opportunities to improve the livelihood and life –support system of locals by reducing uncertainty of human life in arid and semi-arid ecosystems.

STUDY AREA

All areas located on higher elevations or in the upper ridge of Siwalik Hills, perennially face acute scarcity of potable water particularly during the summer months. One of such water deficient areas has been identified at village Dhabi, which is located about 13 Km from NH1A on Dyalachak-Galak Road in Hiraganar Tehsil of Kathua district in Jammu & Kashmir State. The identified catchment is situated almost 30 kilometres uphill side of Indo-Pak International border in mid hilly terrain of lower Siwalik hills and exemplifies a typical water stress area of Kandi belt (Fig. 1 & 2).

The Kandi Belt

In the foot hill zones of the Siwalik of J&K, which stretch between longitudes $74^0$21' to $75^0$45' E and latitudes $32^0$22' to $32^0$55' N, except the western portion extends between River Ravi in East and Munawar Tawi on the West in the Jammu and Kashmir State with its northern limits touching Udhampur and Reasi District. Kandi belt in Jammu & Kashmir State is estimated to be 811 Km^2 in its expanse, of which the upper and lower Kandi belts are 610 Km^2 and 201 Km^2 respectively and located at an elevation ranging between 300 and 490 m above mean sea level many

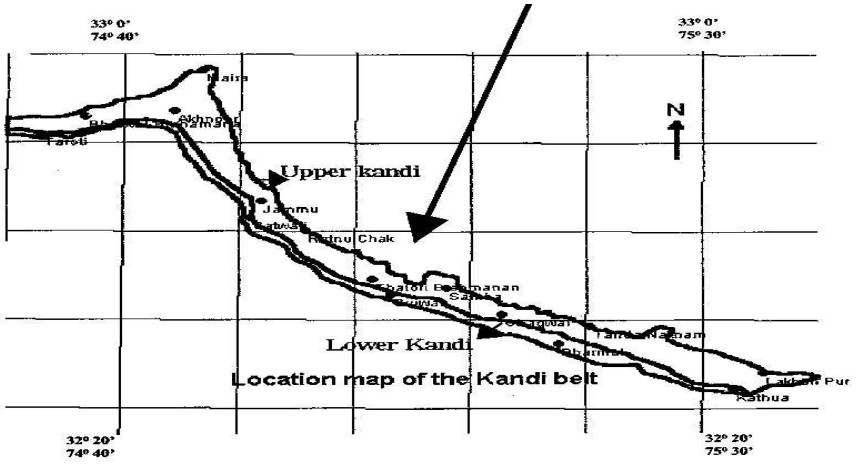

Fig.1. Kandi Belt in India within Jammu & Kashmir

ephemeral streams originate from these undulating hills which facilitate agriculture production in the command area. This Kandi region can be safely divided into smaller watersheds encompassing low-rise but badly degraded hills in the catchment and merging into undulating to flat cultivated lands on their lower limits. The Kandi belt in J&K state is also inhabited by approx. 3.5 million human populations and almost equal number of cattle, thus, necessarily entails to develop this water scarce area on water shed basis to tackle the problem of massive run-off experienced during monsoon, acute water deficiency during summer season, conserve soil and moisture. To address all such challenges, enhanced synergy is needed between the forests and water communities through institutional mechanisms aimed at implementing programmes at local, regional and national levels (Bates *et al., 2008*).

MATERIAL AND METHODS

The study envisages the construction of water harvesting structure insure form of check Dam in the Dhabi Kandi Village for its intended benefits to the local communities.

RESULTS

The results formulated for the proposed construction of the Check Dam for the water harvesting can be divided into following sections;

Why Micro Rain Water Harvesting Structure

Maltha Nallah have limited surface and sub-surface flow for almost 5- 6 months in the year. While its surface water is utilized by the local people to meet their multifarious requirements of their day to day life, it also significantly contributes towards the recharge of dug-well and springs located in the command area. The present watershed is located app.30 Kms from Indo –Pakistan border, as such; much of the run-off water goes as waste due to un-interrupted flow and takes less than one hour to reach the limits of our neighbouring country during peak rainy season & become unable thereafter. Since Maltha nallah is tributary of Tarnah, it ultimately joins river Ravi, thus, don't fall under the ambit of Indus Water Treaty as well. Hence, construction of a concrete dam has been envisaged on Maltha nallah with the basic objective to manage the surface run-off, store the same for prolonged period to make the impounded water available to the people during pinch period besides promoting artificial recharge of ground water as well with the same.

About Check Dam (Percolation Tank)

1. Keeping the catchment area, its gradient and geology in consideration, a 5 meter high concrete *dam* is proposed to be constructed across the Maltha Nallah at village Dhabi, and completed before the onset of monsoon which will act as storage cum percolation tank. (Figs 3-5).

RCC *dam* duly reinforced with steel bars shall provide effective strength to the dam structure to hold massive quantity of impounded run-off water at selected site.

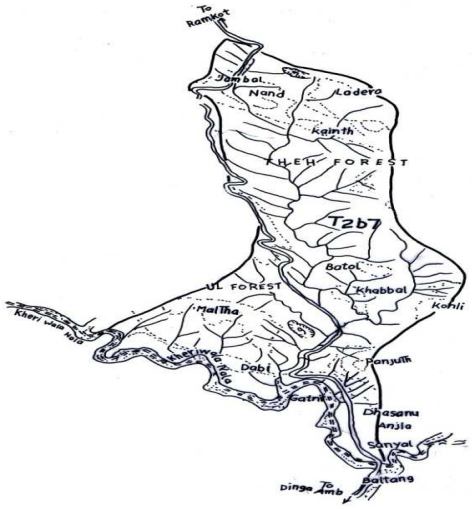

Fig.2.Map of Dhabe -Maltha watershed (scale 1 : 50000)

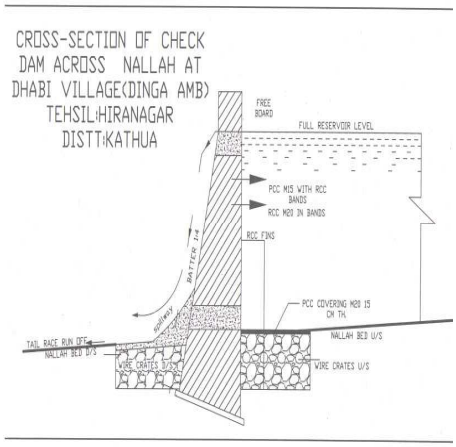

Fig.3. Cross section of Check Dam

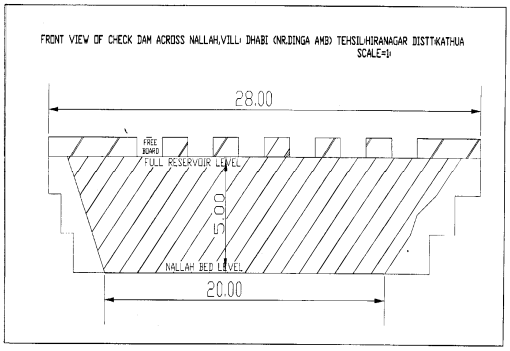

Fig.4. Cross Section of Check Dam –II

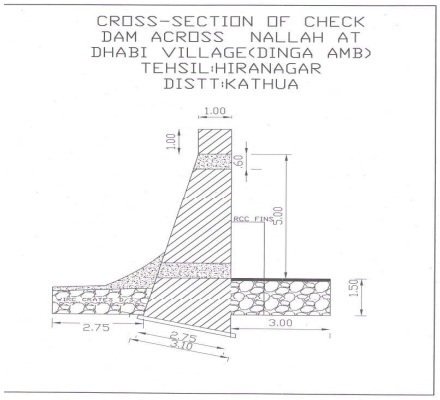

Fig.*5. Front View of Check Dam*

The storage capacity of the *check dam* shall be app. 1,35,00,000 litres (25mx3x180x1000) of water and assuming the life span of *check dam* to be 25 years (and with 5 fillings a year), a total of 168,75,50,000 litres of water shall be impounded after completion of dam structure.

The construction of concrete dam at Dhabi shall ensure water availability equivalent to transporting 126562 water tankers (of 8000 litre capacity each) to this hilly dry belt of Kandi area in Dhabi-Kouli micro watershed from outside , which shall be huge quantity and extremely vital for life support system of the area. Keeping cost of a water tanker at present market rate of Rs. 500/water tanker comes to Rs. 6.32 crores.

2. Keeping the geology, topography, soil texture and other factors of dam site in consideration, it is anticipated that approximately 60 % of the impounded water shall percolate into the soil and recharged to the water table (Jain, 1992). And out of the total storage, it is expected that app. 101,25,00,000 litres of water shall percolate down and recharge the groundwater.

3. The command area of dam is vested with sandstone formations interspersed with clay bed as sub-surface strata, as such, many natural springs / dug-wells exist in the area. One of the objectives of proposed dam is to promote recharging of dug-wells, springs and other water bodies, water table of whom often go significantly down during lean period of the year. Construction of dam and artificial recharge of groundwater shall make availability of water throughout the year in general and during the critical period of the year in particular.

DISCUSSION

The Siwalik Hills of Jammu region are generally water deficient areas and suffer from acute water shortage during the summer months of the year. Besides availability of piped potable water supply to major part of population, it unreliable and low levels of supply in rural areas compel the population to harvest rainwater to meet their domestic needs. The sources of such water for the rural population is through impounding rain water in traditional water harvesting structures like tanks, ponds or by drawing water from existing springs and dug wells. However, with the changing precipitation pattern, its varied periodicity has further compounded the problem and water availability has come under sharp stress and situation becomes quite vulnerable for the local population during summer months. Most of natural springs often witness their progressive drying and water table of dug-wells goes substantially down during summer months while as large number of traditional pond / tanks of Kandi area are either in state of encroachment or grossly ignored due to supply of piped drinking water, thus, most of tanks /ponds are presently in disuse or being utilized much lower to their potential or left with limited scope. However, the status of drinking water in upper undulating hills of Kandi region of the district is really critical. The ground water level in this area is very low as compared to adjoining plains for the reasons that whatever precipitation is received in form of rains during monsoon is lost in the form of surface run-off resulting in considerable shortage of water during large period of the year. The water level in well and springs , which are the only source of drinking water in the area, recedes very quickly & situation becomes highly critical particularly with the on-set of summer season.

Envisaged Benefits of Dam Structure at Dhabi

With the proposed investment of Rs. 24.70 lacs approximately on the dam structure, the economic benefits in terms of sustained availability of water for agriculture, horticulture, vegetable cultivation, farm-fishery and promotion of other production activities in the project area; (cumulative effect of which will result in increased productivity levels, enhanced agricultural output and amelioration of socio-economic conditions of the population whose prime avocation is to practice bio-mass based economy), shall be manifold. Enhanced water availability shall also improve the micro-climate of watershed, enhance forest productivity, promote wild-life, and enhance its bio-diversity. The valuations of multiple ecosystem goods and services generated due

to construction of this dam structure shall be much more than the capital investments.

Primary Benefits

1. Definite recharge of dug-wells, springs and other surface water resources
2. Significant Recharge of Ground water Resources
3. Reliable availability of impounded water to local and their cattle over prolonged periods.

Secondary Benefits

1. Increased agricultural productivity, promotion of horticulture etc.
2. Promotion of new avenues like fisheries, cultivation of medicinal plants, vegetable production, organic farming etc.
3. Improved ecology, enhanced wildlife, bio-diversity, enhancement of ecosystem goods & services.
4. Ameliorated micro-climate, better forest cover and composition, increased growing stock and improved biomass availability.
5. Better employment opportunities for locals in primary, secondary and tertiary sector; which will ensure higher earnings and economical returns for the locals.
6. Improvement in quality of livestock, increased milk, meat and crop production thereby improvement in economic standards and purchase power of locals.

CONCLUSIONS

An improved approach to harvest the surface run-off, by its efficient impounding, prolonged availability and subsequent appropriate management calls for an integrated land-use planning, and engineering measures, flood preparedness, and emergency management in the affected command areas taking into account the socio- economic needs of communities inhabiting both high as well as lowlands. This approach is required to be based on best available scientific knowledge of the causes and environmental, social, and economic impacts of scarcity of water or incidences of floods & environmental and socio-economic effects of such engineering interventions. An appropriate planning and proper execution of such ventures not only provide enhanced opportunities of resources in water deficient areas but is also likely to open many new vistas for perspective ecological, economic and social gains for the marginalized society inhabiting such areas.

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DEVELOPMENTS IN WATER AND WATER RESOURCES LAW IN JAMMU AND KASHMIR: CHALLENGES FOR GOVERNANCE, INTEGRATED MANAGEMENT AND POLLUTION CONTROL

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ABSTRACT

There are two sets of legal frameworks for the management of water resources in Kashmir Himalayas. The older sets of regulations treat water as an inexhaustible resource and focus more on supply of the water and regulation of water related activities. These sets of laws pay little heed to conservation of the water resources. There are, however, scattered provisions in these laws which, in order to protect public health, prohibit activities that contaminate the water. The other framework of laws which is comparatively of recent origin focuses on prevention of pollution and maintenance of the resource for human, agricultural production and other economic purposes.

An efficient legal framework for the management of water resources requires a thorough analysis of existing water codes in order to compliment, improve and reinforce the existing law by incorporating the vital principles of sustainability of the natural resources. The past practice of focusing on supply of water and regulation of water related economic activities has led to a lack of co-ordination between different agencies managing water resources in the state. The Water (Prevention and Control of Pollution) Act, 1974 has added one more official agency for prevention and control of some, and not all of the polluting activities. The Bio-non-degradable Materials (Management, Handling and Disposal) Act, 2007 creates yet another authority with power to prevent entry of bio-non-degradable materials into the water resources. The recently enacted Water Resources (Management and Regulation) Act, 2010 aims to consolidate the regulatory management mechanism but does not disturb the existing pollution prevention and regulation mechanism. The legislations need huge infrastructure, newer technology and manpower to achieve their objectives. In a complex web of several legislations regulating multiple dimensions of water resources, the regulators will have to encounter newer challenges of integrated management of resources , prevention of pollution of water and maintenance of its quality .This paper attempts to explore different legal dimensions of the two systems of laws relating to water resources in the state so as to highlight the problems that

need to be addressed to achieve optimum pollution prevention and resource conservation benefits. The paper is divided into three parts. Part I, as an introduction, gives an account of older laws operating in the state to regulate different aspects of the water resources. Part II deals with recent water resource related laws. Part III attempts to highlight those challenges and problems which these laws need to address for ensuring an efficient legal management mechanism of water resources in the state.

Key Words: Water, Law, resources, Jammu and Kashmir.

INTRODUCTION

The recent legislative water law reform in Jammu and Kashmir has classified the older laws into two types. Those that have been repealed under the new legislation but the rules and regulations framed there-under are partly in operation in one or the other way because the operational parts are not inconsistent with the system envisaged under the new law(The Jammu and Kashmir Water Resources (Regulation and Management) Act,2010). These laws include:
(i).The Water Mills (Jandar and Gharat) Act, 1989 (Samvat);(ii).The Kashmir Valley Embankment Act, 1992 (Samvat); (iii).The Jammu and Kashmir Water Supply Act,1963 , and(iv).The Jammu and Kashmir Irrigation Act, 1978.

The second type of laws include Acts that contain provisions for prevention and control of polluting activities or regulate varieties of economic, tourist ,trade, construction and other activities and their provisions are incidentally relevant to water resources and therefore have not been touched in the recent legislations .These laws can be broadly classified as under:

A) Acts Preventing and Controlling Polluting Activities

i. Canal and Drainage Act, and the Easements Act, 1872
ii. Animal Contagious Diseases (Control) Act, 2006 (1949 A.D);
iii. The Cattle Trespass Act,1920;
iv. The Wildlife (Protection) Act, 1978 as amended in 2002, and
v. The Municipal Act, 2000 A.D.

B) Acts Regulating Economic Activities

i. The Jammu and Kashmir Registration of Tourist Trade Act, 1978;
ii. Camping and Mooring Sites Act, 2004 (1947 A.D.);
iii. Ferry Boats Control Act, 1971;
iv. The J&K State Fisheries Act, 1960 (1903A.D.),and
v. The J&K Water- Nuts (Singhara)Rules, 2007 (1950).

C) Acts envisaging development and Controlling Encroachments and Constructions

i. Development Act, 1970 and the establishment of LAWDA
ii. The J&K Land Revenue Act, 1996(1939A.D.);

iii. The J&K Public Premises (Eviction of Unauthorized Occupants) Act, 1988,and

iv. The J&K Control of Building Operations Act 1988 as amended by the J& K Control of Building Operations Act 1997

Floating Gardens and the law

In addition to the Land Revenue Act, 1939 the J&K Agrarian Reforms Act, 1976 also deals with the concept of floating gardens. The Agrarian Reforms Act has included areas covered by or fields floating over water within the definition of land, making thereby such areas amenable to the provisions of the Act (J&K agrarian Reforms Act, 1976). However, land reserved by the Government for any public purpose is kept immune from the operation of the Act except application of section 38 of the Act. Likewise land owned or held by local bodies is also omitted and kept fully immune from the provisions of the Act. The J& K Lands (Vesting of Ownership to the Occupants) Act, 2001 provides for vesting of ownership rights to occupants of state land for purposes of generating funds to finance development projects in the state (the preamble to the Act).The Act in its section 3 specifically excludes state land covered by fields floating over water, and Kohl (irrigation channel). The funds raised under the Act are to be utilized by the Government for the overall development of the state and its people in areas like education, health, roads, public health engineering, power, irrigation and flood control or any other sector as may be deemed necessary by the high power committee constituted under Rule 3 of the J&K Development Fund Rules, 2007(The J&K Development Fund Rules, 2007).

The New Approaches to Water and Water Resource Governance: Targeting widening challenges of Pollution prevention, maintenance, restoration and conservation

i. The Water (Prevention and Control of Pollution) Act, 1974 and the Environment (Protection) Act, 1986.

The Water (Prevention and Control of Pollution) Act, 1974[hereafter referred to as the Water Act, 1974] establishes a State Pollution Control Board as a nodal agency for effective implementation of the scheme envisaged under the Act for the prevention and control of water pollution and the maintenance of the wholesomeness of water (The Water (Prevention and Control of Pollution) Act, 1974). The Board is to plan a comprehensive programme for the prevention, control or abatement of pollution of streams[i] and wells in the state and to secure the execution thereof as well as advise the State Government on any matter concerning prevention, control or abatement of water pollution. The State Board is to work subject to the directions of the State Government and also in tandem with the Central Pollution Control Board which is itself subject to the overall control of the Central Government. Section 24 of the Act prohibits intentional use of streams or wells for disposal of any 'poisonous, noxious or polluting matter (William, 1993). Similarly no person can knowingly cause or permit to

enter into any stream any other matter which may either directly or in combination with similar other matters impede the proper flow of the water of the stream and which may substantially aggravate the pollution due to other causes or of its consequences .A prior consent from the state Board is required to establish any industry, operation or process, or any treatment and disposal system or an extension or addition thereto, which is likely to discharge sewage or trade effluent into a stream or well or sewer or on land; bring into use any new or altered outlets for the discharge of sewage or begin to make any new discharge of sewage.

The Environment (Protection)Act,1986 defines environment in a comprehensive way as including water, air and land and the interrelationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organism and property (Environment (Protection) Act, 1986). The words 'environmental pollutant' and 'pollution' under the Act denote any solid, liquid or gaseous substance present in the environment in such concentration as may be, or tend to be, injurious to environment. Extensive powers have been conferred upon the Central Government for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution which may be delegated under section 3 (3) and section 4 upon different authorities and officers specially constituted or designated under the Act. Persons carrying on any industry, operation or process cannot discharge or emit any environmental pollutant in excess of the standards prescribed under different Schedules of the Environment (Protection)Rules,1986.In the state of Jammu and Kashmir the State Pollution Control Board has been delegated with various powers including the power to give directions and order closure ,prohibition or regulation of any industry, operation or processor stoppage or regulation of the supply of electricity or water or any other service. The State PCB, therefore, can directly intervene to protect and improve the quality of the lakes and take steps for the prevention, control or abatement of any of the environmental pollutants.

ii. The Jammu and Kashmir Non-Biodegradable Material (Management, Handling and Disposal) Act, 2007

The Jammu and Kashmir Non-Biodegradable Material (Management, Handling and Disposal) Act 2007 is a recent state legislation to prohibit and regulate handling and disposal of non-biodegradable material in the state and the matters connected therewith.(The Jammu and Kashmir Non-Biodegradable Material (Management, Handling and Disposal) Act, 2007.Section 2(d) defines Non-biodegradable material as those materials which cannot be decomposed or degraded by action of microorganisms, sunlight or other natural actions and includes goods made or manufactured from polythene, nylon or other plastic substances specified in the schedule of the Act, and also includes non-

biodegradable waste and garbage. The Act empowers the government to appoint/ constitute a prescribed authority to excises the powers and perform the functions under the Act. The government can confer the powers of such authority on any existing agency working in the field of pollution abatement. Accordingly the State Pollution Control Board has been conferred with the powers of prescribed authority under the Act. The Government after consulting the prescribed authority can declare non-biodegradable material control areas. Use of Non- biodegradable materials of any kind may be banned, prohibited or restricted in such declared area if its use is likely to result in environment, health or other problems.

Section 8 of the act authorizes the prescribed authority to prescribe the manner in which any non-biodegradable material may be handled or disposed by the people. Where any land or building has become a dumping place or ground for unauthorized stocking or deposit of such material and is likely to cause nuisance or damage the drainage and sewerage or is likely to result in danger to life and health, the authority may forthwith take steps necessary at the cost of such person.

Under Section 9 no person ,by himself or through another ,shall knowingly or otherwise, throw or cause to be thrown, in any drain, ventilation, shaft, pipe and fittings, connected with the private or public drainage works, natural or manmade lakes, wetlands any non-biodegradable garbage or construction debris or any biodegradable garbage by placing in a non-biodegradable bag or container likely to injure the drainage and sewage system; interfere with the free flow or affect the treatment and disposal of drainage and sewage contents; be dangerous or cause a nuisance or be prejudicial to the public health, and damage the lakes, rivers or wetlands.

The section also prohibits placing of any bio-degradable or non-bio-degradable garbage in any public premises open to public view, although it can be placed in receptacles or deposited in locations designated by a local authority with jurisdiction in the area. Rule 6 of the Jammu and Kashmir Non-Biodegradable Material (Management, Handling and Disposal) Rules, 2009 (SRO 122, of,2009) framed under the Act impose a responsibility upon the owners and occupiers of premises not to throw non-biodegradable material generated during construction activities in drains, nallahs, sewers, wetlands ,water bodies or on the surface land but handover such material to the municipal authorities for proper disposal .The rules further strengthen the hands of the prescribed authority by imposing responsibility upon municipal bodies/ committees and district magistrates/deputy commissioners to implement the provisions of the Act in their respective jurisdictions.

An omission or commission in contravention of any of the provisions of the Act or of any rules, notifications or orders made or issued under the Act is punishable with imprisonment up to one month or fine up to Rs. 500or both .Punishment for the second or subsequent offence may extend up to 2 months and fine up to Rs. 10,000. Aiding,

abetting or assisting in the commission of an 0ffence is punishable as in the case of a principal offender. Section 11 holds companies as well as their responsible and in charge officials liable for contraventions committed by them. Offences are made triable in a summery way by judicial magistrates of First class but are made compoundable, before the institution of the prosecution by an authorized officer; on payment of such sum as such officer may order. The sum, however, in no case can exceed the amount of fine prescribed for such offence[ii]. The provisions of the Act are expressly declared to be in addition and not in derogation of the provisions of any other law for the time being in force on the subject.

iii. The Biological Diversity Act,2002

The Act is not directly related to water but aims to conserve the biological diversity including aquatic resources, sustainable use of their components and fair and equitable sharing of benefits arising out of utilization of genetic resources. In addition to a National Biodiversity Authority the Act mandates the establishment of State Biodiversity Boards by each of the states to advise the respective state Governments on conservation ,sustainable use and equitable benefit sharing by local communities of biological resources. The Act also empowers a State Biodiversity Board to regulate ,by approvals, commercial utilization of biological resources and declare areas of biodiversity importance as Biodiversity Heritage Sites.

iv. The Wetlands (Conservation and Management) Rules, 2010

The Wetlands (Conservation and Management) Rules, 2010 have been framed by the Central Government under the provisions of the Environment (Protection) Act, 1986 and are accordingly applicable to the state of Jammu and Kashmir. The Rules recognize that many wetlands are seriously threatened by reclamation through drainage and landfill, pollution (discharge of domestic and industrial effluents, disposal of solid wastes), hydrological alterations (water withdrawal and inflow changes) and over-exploitation of their natural resources resulting in loss of biodiversity and disruption in goods and services provided by wetlands (Wetlands (Conservation and Management) Rules, 2010). Consistent with the mandate of the Ramsar Convention and the National Environmental Policy, 2006 to maintain the ecological character of wetlands, the Rules set up a regulatory mechanism for the following types of wetlands:

Protected Wetlands

i) Wetlands categorized as Ramsar wetland of international importance under the Ramsar convention as specified in the schedule.

ii) Wetlands in area that are ecologically sensitive and important, such as, national parks, marine parks, sanctuaries, reserved forests, wildlife habitats, mangroves, corals, coral reefs, areas of outstanding natural beauty or historical or heritage areas and the areas rich in genetic diversity;

iii) Wetlands recognized as or lying within a UNESCO World Heritage Site;

iv) High altitude wetlands or high altitude wetland complexes at or above an elevation of two thousand five hundred metres with an area equal to or greater than five hectares;

v) Wetlands or wetland complexes below an elevation of two thousand five hundred metres with an area equal to or greater than five hundred hectares.

vi) Any other wetland as so identified by the authority and thereafter notified by the Central Government under the provisions of the Act for the purposes of these rules

The Rules prohibit certain activities within the wetlands. These activities include reclamation of wetlands, setting up of new industries and expansion of existing industries, manufacture or handling or storage or disposal of hazardous substances, solid waste dumping, discharge of untreated wastes and effluents from industries, cities or towns and other human settlements, any construction of permanent nature except for boat getlies within 50 metres or any other activity likely to have an adverse impact on the ecosystem of the wetland.

The State Government is empowered to authorize undertaking of certain activities like withdrawal of water or the impoundment, diversion or interruption of water sources within the local catchment area of the wetland ecosystem, harvesting of living and non- living resources therein, grazing, treated effluent discharges from industries, cities or towns, human settlements or agricultural fields within the limits laid by the CPCB/SPCB, dredging, only if the wetland is impacted by siltation. However the State Government is required to ensure that a detailed EIA is carried out in accordance with the procedure specified in EIA Notification of September 2006 as amended from time to time. The Central Government has, however been conferred with a paramount power to permit any of the prohibited activities or non wetland use (including conversion of a wetland to non-wetland use) on ground of expediency in the public interest.

The Rules provide for the constitution of Central Wetlands Regulatory Authority (CWRA) with powers to appraise proposals for identification of new wetlands, projects or activities in consultation with the concerned local authorities. Decisions of the CWRA can be appealed against by aggrieved persons only before the National Green Tribunal. The wetlands specified in the schedule are made subject to the regulations under the rules. The Schedule includes 24 wetlands of India and the wetlands from J&K State included in the Schedule are Tosmoriri, Wular lake, Hokarsar and Surinsar and Mansar (Complex).

The State Governments are required to prepare 'Brief Document' identifying and classifying wetlands within their respective territories in accordance with the criteria laid down in Rule 3 and submit the same to the Central Wetlands Authority. The Authority may, if needed, and in consultation with the State Government refer it to an institute or

university with multi -disciplinary expertise related to wetlands for survey in terms of the criteria specified in Rule 3. The Central Government may, on receipt of recommendations of the Authority and after due consideration of the objections and suggestions from the effected general public, issue notification notifying the area of the wetland, its category or classification to be regulated under the Rules. The Authority has been conferred with a power to suo motto review its any decision or issue direction for inclusion of wetland under the Rules.

In order to avoid overlapping, wetlands falling within National Parks and Sanctuaries are left to be regulated by the provisions of the Wildlife. (Protection) Act, 1972 and those falling within the protected or notified forest areas are to be regulated by the provisions of the Forest Act, 1927 and Forest (Conservation) Act, 1980 and the Environment (Protection) Act, 1986. The gaps in the regulation of wetlands within the protected and notified forest and wildlife areas under the Forest and Wildlife laws are to be plugged by involving provisions of the Environment (Protection) Act, 1986. The Wetlands situated outside the protected or notified forest areas are also to be regulated by the provisions of the Environment (Protection) Act, 1986. The Forest Department of the concerned State is to regulate the activities for management and wise use of wetlands situated within protected or notified areas. But the identified activities for management and wise use of wetlands situated outside the protected or notified forest areas are to be regulated by the nodal department or the relevant local state agencies designated by State for the said purpose. The State Government in J&K has constituted wetland specific authorities within the state for their development. Clearly, therefore, management of wetlands and regulation of activities therein is left in the realm of multiple authorities where co-ordination may often turn to be causality.

v. The Jammu and Kashmir Water Resources (Management and Regulation) Act, 2010

The Water Resources Act,2010 aims to consolidate the law relating to use of water, the measurement, construction, control and management of works with respect to water storage, conservation and protection, the irrigation, water supply, drainage, flood control and prevention, the improvement in the flow of water, the protection and improvement in the physical integrity of water courses, lakes and springs, the safety and surveillance of dams, the establishment of the State Water Resources Regulatory Authority for regulating water resources, ensuring judicious, equitable and sustainable management, allocation and utilization of water resources, fixing the rates for use of water and matters connected therewith or incidental thereto (The Jammu and Kashmir Water Resources (Management and Regulation) Act, 2010).

The Act makes every water source in the state as the property of the state government and any proprietary ownership, or any riparian or usage right on water resources vested in any individual, group of

individuals or any other body, corporation, company, society or community is, from the date of commencement of the Act to be deemed to have been terminated and vested with the Govt. No person can use any water from any source, surface or ground, or collect or extract any material from water sources except in accordance with the provisions of the Act.

The Act introduces a licensing regime of water usage for domestic, (sections 5-23) commercial and irrigation purposes (sections 24-51) which are made subject to tariffs, charges and other conditions. Part III of the Act (sections 52 –55) deals with drainage and prevention of water logging. In regulating the irrigation supplies (sections 56 –65)the irrigation authorities , the Chief Executive Engineer and Chief Agricultural Officer of a district are empowered to restrict landowners to grow, plant or sow particular crops having regard to the soil characteristics, climate, rainfall and availability of water. Persons who sow, grow or plant unauthorised crops are made subject to penalty and payment of higher rates of water charges (section 62).

Section 63 provides for preparation in the public interest of small schemes for irrigating lands not exceeding 100 hectares. After the preparation of the scheme is accomplished the management of the scheme and distribution of water there from is to be left in the hands of a water Committee composed of five persons to be elected by land owners, occupiers and beneficiaries of land included in the scheme for a period of 3 years (Section 64). Part –V of the Act provides for measures for ensuring safety of irrigation works. Fishing or plying of boats etc in a reservoir, pond, tank, or across a water course or channel, maintained or controlled by the Government, without proper permission is prohibited. The Act also imposes prohibitions on abstraction of water, deposition of any material or waste in or near a water channel and discharge of sewage or industrial effluent in an irrigation work. In order to control floods the Act provides for declaration of flood basin areas, safety of embankments, and control of bed and banks of water sources, navigation channels, intake channels, city channels and flood spill channels[iii].In Chapter-V of the Act a compensatory mechanism is envisaged for damages to crops, trees, buildings or other property ensued due to execution of any irrigation or flood control related work or operation.

Any person, group of persons, Government Department, local authority, corporation, company or society or other body intending to install a unit requiring usage of water for generation of electricity, irrigation, drinking purposes (domestic, commercial, industrial or institutional), running of water mills or exploration and exploitation of ground water has to obtain a license after submission of a plan and its approval by the Authority. The plan has, however, to be consistent with the State Water Policy. The state however cannot permit use of water for generation of electricity under the licensing system or for irrigation projects in a manner that undermines or bypasses the requirement of

EIA in the cases specified under the EIA Notification of September 2006(EIA Notification, 2006).

Amongst the series of water related laws operating in the state the Water Resources Act, 2010 is the first legislation that provides for the development, regulation and management of ground water resources in the state (The Water Resources Act, 2010). The state, on the advice of the authority, is empowered to notify areas for the development and regulation of ground water. Extraction and use of ground water in such areas can be made only after obtaining license from the authority. Extraction and use of ground water through hand operated manual pumps or other manual devices in private lands does not, however require such a license. In order to endeavour ground water recharge programmes both in urban as well as rural areas, the authority is to identify the areas , strategies , types and designs of structures to promote rain water harvesting including especially through roof-top rain – water harvesting methods.

The Act provides an in-house grievance redressal and adjudicatory mechanism for the consumers of water; it bars jurisdiction of civil courts though decisions and orders of the Authority can be appealed by the aggrieved before the High Court of J&K. For the speedy trial of offences the Act also envisages constitution of special courts and empowers CJM's to take cognizance of offences on the basis of reports by police or complaints made by authorised officers .The state police is also conferred with jurisdiction to take cognizance of the offences under the Act. The Act, amongst the series of other offences, makes it an offence to dispose off house- sewage or other house- hold waste into any water source. The penalties imposed under the Act are in addition to any other liability e.g. compensation and revocation of licenses. The Act does not bar punishment for acts under any other law, if such acts are also made punishable under such other laws in force. Some of the offences which may be committed by consumers, licensees and other persons have been made compoundable with power vested with authorised officers to receive compoundable sums fixed for different offences under the Act.

The provisions of the Act are in addition to and not in derogation of existing related laws. The provisions of the Act are to have effect notwithstanding anything inconsistent in any other law in force in the state. The only exception to this overriding effect of the Act in case of inconsistency with other laws is the law relating to consumer protection in force in the state. Obviously therefore, the Act is subject to all the principles relating to protection of consumers under the consumer legislation.

Consistent with the National Water Policy, 1987,2002 of the Government of India the Act mandates the Government of J&K to prepare, from time to time, State Water Policy and plan for the development, management, planning, utilization and monitoring of water resources in the state which shall keep the following objectives in view:-

Designing future water plans and policies by the state: the statutory mandate and guidelines as policy challenges for water governance

For the development, management, planning, utilization and monitoring of the water resources in the state the state Government is mandated to prepare state water policy and plans from time to time which shall be in tune with the objectives enumerated in section 4 of the Act. Most of these objectives are policy challenges which cannot be achieved overnight but can serve as a blueprint for an efficient water governance regime with a firm scientific base.

Coordination, Conservation and water allocation prioritization

The Act aspires for the development by the state of an effective institutional mechanism for coordinating the management of water resources on a hydrological unit basis with a multi sectoral and multi disciplinary approach. Likewise the water policy shall stress upon an integrated and multidisciplinary approach to planning, formulation, clearance, implementation and monitoring of water projects and schemes including catchment treatment and management, and ecological aspects. Such an approach shall ensure involvement of users, farmers and voluntary organizations in various aspects of planning, design, development and management of water resource schemes (both for drinking water and irrigation). The rehabilitation of affected people and command area development should also form part of the water policy.

Policy initiatives will have to stress more on efficient water utilization and public awareness of the importance of its conservation. Innovative techniques based on science and technology will have to be pressed into service to eliminate pollution of water resources and promote recycling and reuse of water. Planning, development and conservation of the water resource has to be made on an integrated and environmentally sound basis. The state is to follow the following scheme of prioritization in the allocation of water, subject to modifications if so warranted by area /situation specific considerations:

(i) drinking water including washing & bathing ;(ii) irrigation ;(iii) generation of electricity ;(iv) ecology; and (v) agro Industries and non-agricultural industries.

In the planning and operation of systems water allocation priorities should be fully ensured. In this context the drinking water needs of human beings should be the first charge on any available water. The Act, besides above, enshrines the following policy challenges to be endeavored by the state:

1. **Information System:** A well developed information system with a network of data bank and quality data bases is a prime requisite for proper resource planning. Accordingly the Act stresses upon the development of information system to collect, process and provide data regarding the availability of water, actual use of water for different purposes, the

future demands of water for diverse purposes, hydraulic data with emphasis on the use of modern technology including remote sensing techniques. The state is therefore mandated to establish a network of data banks and data bases using modern computer technology and exchange of data among the various agencies .Such a system can integrate and strengthen the existing agencies and facilitate free exchange of data among them. The data base through GIS can facilitate comprehensive and reasonably reliable projections of future demands for water for diverse purposes.

2. **Maximizing Availability:** Water resource being utilizable resources, need to be conserved and the availability augmented by measures for maximizing retention and minimizing losses, it should be made available to water shortage areas by transfer from other areas.
3. **Project Planning:** Water resource development projects should include comprehensive EIA to evaluate maintenance, modernisation and safety of the structures and system created through massive investments like hydro projects, dams etc should be ensured through monitoring by proper guidelines, continuous surveillance and regular visits by experts.
4. **Ground water development:** There should be an integrated and coordinated development of surface and ground water and to ensure their conjunctive use. Ground water resource regulation should ensure social equity and avoid over exploitation so that it does not exceed the recharging possibilities.
5. **Preservation of environmental quality and minimisation of adverse impact:** In the planning, implementation and operation of projects preservation of the quality of the environment and the ecological balance should be a primary consideration. The adverse impact on human lives, settlements, occupations, economic and other aspects and the environment need to be minimized and offset by adequate compensatory measures.

The integrated management and pollution prevention challenges

The right to water as a human right entitles its holder to water that is sufficient, safe, of acceptable taste, physically accessible, as well as affordable. These characteristics have been divided into availability, quality and accessibility with a corresponding obligation on the state to respect, meaning no interference, protect, from third parties, and fulfil, which means to facilitate, promote and provide(Development Law update,2006).Water as a resource is one and indivisible whether it is from rainfall, rivers, surface ponds, lakes or from ground. These resources as a whole are all parts of one system and part of a larger ecological

system. Success in their regulation can be measured in terms of what net efficiency gains are being transferred to the society. This however requires extensive institutional development in water resource management. Although enactment of good laws is the first step to legal reform, its effectiveness depends on the more crucial step of restructuring the institutions to implement the new law as these institutions are often most resistant to change, due to negative effects the change may have on them. it is being argued that in developing countries the most challenging issues to god governance are fight against corruption, both at government and private level (McDonnell,2008).

The plethora of laws operating in the water resources field creates diverse authorities who are invested with multiple powers and responsibilities under the individual legislations. Howsoever earnestly the individual officers and authorities may endeavour to exercise these powers strictly in terms of the objectives of the individual legislations, it will be an exercise of power with a myopic objective in view where the larger objectives of other legislations may either be undermined or not fully considered for lack of expertise or coordination in other related fields. This problem may assume greater proportions under central and state legislations which create/establish central and state authorities or agencies to deal with a common water resource.

Planning and implementation in respect of flood control, irrigation (both individual and multipurpose) and power generation involve a wide range of issues like environmental protection, rehabilitation of project affected people and live stock, public health consequences, dam safety etc. The growth process both in population and economic activities inevitably lead to increasing pressures and demands for scarce water resource, for human, industrial, agricultural, hydro-power, environmental, recreational and other purposes. Distribution of water, therefore, involves complex problems of equity social justice and environmental protection. Development and exploitation of ground water resources also gives rise to questions of judicious and scientific resource management and conservation.

All these questions need to be tackled on the basis of common policies and strategies. Besides, implementation requires the technical, financial and administrative capacity to administer the law. This necessitates the need for capacity building in all water related regulatory spheres to ensure fulfillment of policy objectives. Further, to achieve the desired objectives it is necessary to make water users as instrumental part of implementation and provide communities with opportunities of self policing and self implementation through water user associations. Clearly, therefore, there is an utmost urgency to establish a common grid for diverse regulatory authorities which can act as a common platform for informed decision making and facilitate an integrated, coordinated approach to water resource management in the state.

For good governance in an integrated water resources management it is fundamental that efficient, balanced and equitable decisions are made. However, for informed decision-making, both reliable and timely information must be available. Once Geographical Information System (GIS) and associated data bases to develop information infrastructure is pressed into service, it will have several beneficial impacts upon the water governance. Information will be easily accessible and decision making will be endeavored and based on a wide and integrated knowledge of an area. Easy access of information even to organizations and stakeholders not directly concerned with water management will ensure that water issues are considered in decision making in other sectors and levels of government other than the concerned agencies. Besides the role of the civil society will be enhanced by easy access to information which will ensure informed and empowered public participation. But in the development of information support system there can be administrative and political challenges as well. One of the political challenges will be the task of developing equitable, efficient and safe water and sanitation services. Though data gives power its collection and management involves financial cost that is why departments, in the absence of a common grid, may show reluctance to share data with other (rival) departments which may constrain them to use other legal tools like RTI Act to overcome the difficulties.

GIS based information needs technology and skills at the infrastructural level and availability of data from various sources, operational and managerial inputs and analysis to ensure sound and unbiased viability of data. At present on the shelf existing methods are being used which limit the opportunities for an integrated water resources management To operationalize the new techniques it has been suggested to work in tandem with those in Geographic information science, ecology and social sciences to develop new methodological approaches to achieve integrated water resources management ambitions and ensure returns of equity, efficiency and sustainability.

The basic objective of the water Act, 1974 is prevention and control of pollution and the maintaining or resolving of wholesomeness of water. To achieve this, the Act flatly prohibits discharge of any pollutant into the waters without a consent and compliance with standards and treatment requirements. No doubt this is the first step quite essential to restore the integrity of waters but reduction of pollution is not enough to achieve the broader objectives. Once the objective of restoration is achieved, there must be an adequate mechanism for maintaining the wholesomeness of water. In J&K Water Resources Act, 2010 fills this gap.

From a biological monitoring point of view, the ecological impairment of a water body can be caused by flow reductions, channelization, loss of riparian wetlands or flood plain habitat etc. These aspects need a direct mechanism to ensure corrective measures other than numeric water quality based effluent limits for point sources. No

doubt the Water Act defines pollution as contamination of water or alteration of its physical, chemical or biological properties, the Act hardly provides a clear cut programme for all significant sources of aquatic ecosystem impairment. The principal of sustainability suggests a better integration of water quality and aquatic ecosystem restoration and protection with water resources management. A more systematic approach needs to be put in place for implementation in order to restore and maintain the chemical, physical, and biological integrity of state's waters and aquatic ecosystem.

The Water Act was designed during a period when industrial sources of pollution were viewed as most severe. The Act is primarily designed to control point source pollution from industrial units and municipal points .It has duller teeth to control non point sources of water pollution. Agricultural runoff, animal wastes, soil erosion, fertilizers, pesticides and other farm chemicals that are a part of runoff, construction runoff and siltation from mines are major contributors to the states water pollution problem. Viewed thus it can hardly serve the purpose in an increasingly post industrial era in which non- industrial pollution sources, in view of given economic and land use pressures, are assuming greater significance. Clearly therefore, quality of water cannot be restored or maintained unless the complex and difficult problem of non point sources is addressed. In order to fill the gap between industrial and non- industrial pollution sources it is desirable to adopt a mandatory system of enforceable best practice standards for polluted runoff and other kinds of non- point source pollution analogous but not identical to the system of technology based controls on municipal and industrial point sources. Such standards should however be flexible to accommodate differences in climate, soils, topography, land use, economic and other factors.

Massive migration to urban and sub-urban areas and sprawl are rapidly threatening integrity of water resources because of multiple discharges with significant environmental implications particularly the radical alterations in the hydrology other than characteristics of the water around the state. Today there is a shifting paradigm of environmental regulation. It is now well recognized that instead of end of the pipe pollution loads there are increasingly significant impacts arising from the distribution, use and disposal of products and a wider regulatory perception is needed to encompass this. Action based upon life cycle thinking about products has the potential to be more effective than trying to address diffuse pollutants through land use regulation and is certainly more effective than regulating end of the pipe emissions. To overcome these challenges it has been suggested in some other countries that future strategies for water pollution control now must be tailored to the problems and realities of a post industrial society.

From 1974 till date Parliament of India has adopted many amendments to water Act, 1974 but most of these revisions added

or changed details without changing the basic philosophies and implementing methods. Viewed from the broader statutory objective to restore and maintain the wholesomeness of water, the statutory tools are either dull or in some cases inadequate to accomplish the task. The appropriate tools have yet to be forged. The Act focuses more on maintenance than on restoration, on chemical integrity to the virtual exclusion of physical and biological integrity. It is time to retool the Act to address these statutory goals that have received relatively less attention and to focus on the prevailing threats to the health and integrity of aquatic ecosystem.

Both the Water Act, 1974 & the [J&K] Water Resources Act, 2010 provide for formulation of comprehensive plans in respect of water quality .While the SPCB implements centrally set uniform controls (standards) on industrial units and sewage treatment plants, the State Government is better suited to address land use and other non- point source pollution problems that vary widely with different local geography, climate topography, economics and other factors. There is however absence of representation inter se the SPCB and the Water Resources Authority to attain the common goal of maintaining the quality of water. The Water Resources Authority is composed of 3 members only while the SPCB comprises of several members, the State Government can fill this gap while constituting the two bodies, though due representation in the two bodies of members inter se ought to be a regular feature rather than a matter of casualty. Alternatively a joint sub-committee is recommended to facilitate a co-ordinated and integrated decision making on regular basis and both legislations have space in their provisions to accommodate formulation of such committees.

The Water Resources Act, 2010 has put an end to the traditional riparian doctrine for wider societal needs and introduces a license based regime of water use, investing the state with responsibilities as trustee of all water resources. Being at the embryonic stage, it can be said to be a positive step in the right direction so as to achieve policy goals and chart a sustainable future for state's water resources. The use of underground water through traditional hand pump practice in private lands is not changed and would continue to attract the riparian principles for adjudication. However regulation of licensing under the Water Act, 1974 and the Water Resources Act, 2010 may result in disputes demanding settlement of jurisdictional issues under the two adjudicatory systems provided under the two Acts and other related laws.

To sum up, water reforms in the state need to focus not merely on organizational issues but on the governance of the relationship between the regulator and the user. Due to climate change ,glacial melt in the Himalayas is projected to increase flooding, rock avalanches from destabilized slopes, affect water resources and decrease river flows as the glaciers recede, decrease fresh water availability, impinge on sustainable development as it may

compound the pressures on natural resources and the environment associated with rapid urbanization, industrialization, and economic development (IPCC,2007).Under such circumstance the growing demand on resources across competitive users, declining water quality, inadequacy of safe drinking water, increasing droughts, unabated flooding ,increasing financial crunches can mount newer types of pressures and problems which the regulators will have to tackle. This may in turn demand flexibility in laws to allow regulators to make adjustments and adapt it to the changing climatic conditions. Presently environmental law and policy are not keeping up with the need for adaptation. For example, environmental and natural resources laws are currently based on assumption of ecological stationarity and pursue goals of preservation and restoration. These assumptions and goals do not fit a world of continual, unpredictable and non-linear transformations of complex ecosystems that the climate change is creating (Craig, 2010).

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LITHOLOGICAL CONTROL OF SOLUTES IN TWO FRESHWATER LAKES (WULAR AND MANASBAL) OF KASHMIR VALLEY, INDIA: IMPLICATIONS TO LITHOGENIC AND ANTHROPOGENIC SOURCES

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ABSTRACT

Wular Lake (largest freshwater lakes of Asia) and Manasbal Lake (deepest freshwater lake of valley) located in Kashmir, were studied to comprehend divergence in water chemistry in June, 2006. Lake water samples (N=20) from each lake, were collected for the analysis of pH, EC, TDS, Ca^{++}, Mg^{++}, Na^{+}, K^{+}, HCO_3^{-},SO_4^{-},CO_3^{-} and Cl^{-}. The study revealed that both Manasbal and Wular water's were alkaline {(Wular, pH: 7.5 – 8.9); (Manasbal pH: 7.4 – 8.2)}. The concentration of E.C (203.12 – 271.87 uS/cm), T. D.S (130 - 174 mg/l), Ca^{++} (11.2 - 23.3 mg/l), Mg^{++} (6.2 – 12.4 mg/l), HCO_3 (90 - 120 mg/l), SO_4 (1.3 – 7.9 mg/l) were recorded moderate in Manasbal Lake. However the faintly higher concentration of constituents Na (2.1 – 8.3 mg/l) and Cl (4.1 – 8.9 mg/l) in Manasbal water samples is attributed to the maximum rock water interaction as the lake is fed mainly by spring waters. The slightly higher concentration of chloride (Cl:1.4 – 6.9 mg/l) and SO_4 (7.3 – 20.3 mg/l) in Wular reflect the impact of sewage as the Lake is fed mainly by River Jhelum which passes through the rural urban areas of valley, carries waste with it and later deposits into Wular Lake. Concentrations of most of the major ions were recorded moderate in Wular Lake Ca^{++} (9.2 – 23.8 mg/l), Mg^{++} (2.4 – 13.9 mg/l), Na (1.1 – 3.6 mg/l). Only one hydrochemical facies, Ca-Mg-HCO_3, was identified using piper trilinear diagram which is also supported by langlier-diagram indicating the dynamic nature of the lake which flushes the water frequently. The conceptual model of Ca^{++} + Mg^{++} Vs HCO_3, Ca^{++} + Mg^{++} Vs HCO_3 + SO_4 and Na+K Vs Cl suggested chemistry of lake waters is mostly controlled by rock-water interaction and bear the imprints of lithological control. The study suggested that the chemical quality of the lake water is within the permissible limit given by WHO and hence good for domestic purposes.

Key words: Water chemistry, rock water interaction, anthropogenic, Wular, Manasbal, Lithology.

INTRODUCTION

Lakes, the inland bodies of water, play an important role in the economy of a region or country and are of tremendous academic, societal and economic importance. They act as natural water reservoirs and store large quantity of water, which can be used for drinking, industrial, irrigation, aesthetic, hydro-power generation, water spots, etc. Kashmir is blessed with a number of lakes with different hydrological settings such as Manasbal lake (fed mainly by groundwater), Dal lake (fed mainly by fresh water streams) and Wular lake (fed mainly by the river Jhelum), Anchar Lake (fed mainly by sindh nala). (Raza et al. 1978; Keller 1985; Sharma and Bakshi 1996; Kapoor and Das 1997; Hussain 1998; Khan *et al* 2006) Studies on lakes in Kashmir valley are very important as information on high altitude lakes is very rare in India (Hamilton and Schaldow 1997; Bhatt 2004). The water quality of the lakes in Kashmir is not monitored regularly and data on the water quality and Lithological control of solutes in Wular and Manasbal lakes are very meager.

It is important to study the Lithological control of solutes; as these lakes serves as an important natural water reservoirs for the local population further their water is used for drinking and agricultural purposes.

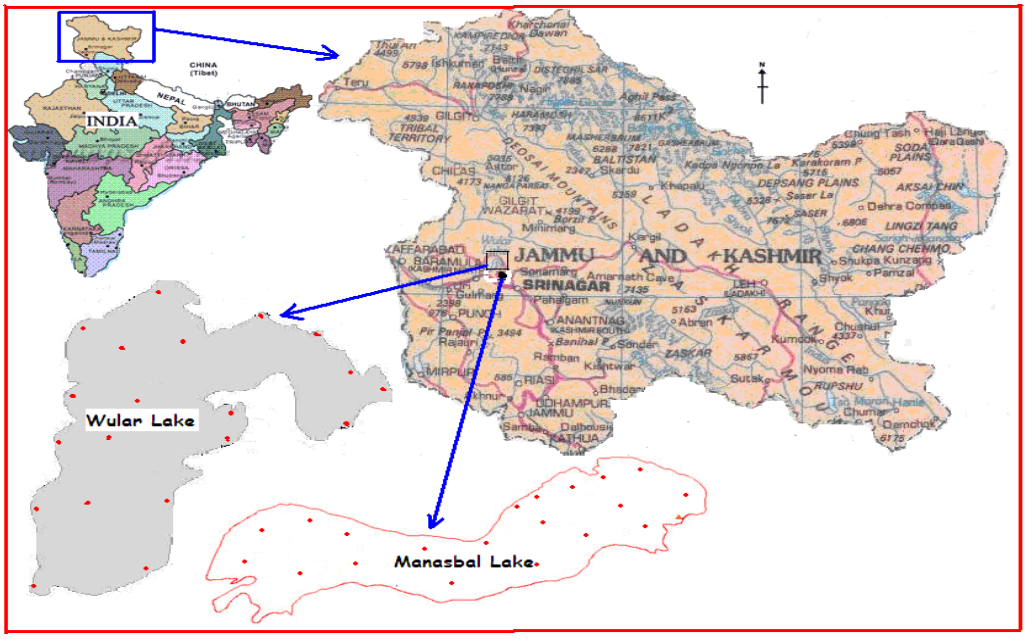
Study area

Wular Lake and Manasbal Lake are at a short distance from each other in kashmir valley with diversity of lithology in their catchment areas (fig.1). Both are freshwater lakes, Wular lake is fed by River Jehlum while as Manasbal by internal springs. Wular Lake situated towards the north and northeast of valley, lies between 34^0 15^- and 34^0 25^- latitude, 74^0 30^- and 74^0 40^- longitude and area varies from 30 to 260 km sq. Lake is fed mainly by River Jehlum, enters lake from southeast and leaves it from west. Streams like Madurmati and Erin enter the lake from eastern side.

Manasbal Lake towards North West of Kashmir valley, is the deepest (12 m deep) of all the freshwater lakes fed by groundwater (Lawrence 1895; Raina 1971). It is situated at an altitude of 1583 m amsl. It lies between 34°15'N latitude and 74°40'E longitude and covers an area of about 280 ha of which 25 ha is marshy (Sara, 2011)

MATERIAL AND METHODS

Twenty water samples from each lake (Wular and Manasbal) were collected from various locations, in high density polyethylene (HDPE) bottles. Analysis was carried out according to standard methods of APHA 1992. The pH and electrical conductivity (EC) were determined in the field with the help of water analysis kit. For major ions description samples were filtered through <0.45 um nucleopore filter paper. The concentration of Ca^{2+}, Mg^{2+}, Cl and HCO_3 were determined by volumetric methods, Ca^{2+} and Mg^{2+} by EDTA titration, Cl by $AgNO_3$ titration. Na^+ and K^+ concentrations were determined by means of flame emission photometry. Sulfate and NO-3 were analyzed by gravimetric and spectrophometric methods, respectively.



Fig;1: Map of study area including sampling locations

RESULTS AND DISCUSSION

Water Chemistry

Chemical characteristics of both the lakes are different from each other, primarily due to diverse lithology in the individual catchments and magnitude of anthropogenic inputs. Wular and Manasbal waters both are alkaline in nature (Table-1), having comprehension of (pH: 7.5 – 8.9) and (pH: 7.4 – 8.2) respectively. pH from the lakes indicates removal of CO_2 during photosynthesis and in the process the water becomes super saturated with calcite (Das, 2003).Electrical conductivity (E.C : 105.31 – 249.37 uS/cm), total dissolved solids (TDS: 67.4 –159.6 mg/l) were recorded lesser in wular Lake compared with Electrical conductivity (EC: 203.12 – 271.87 uS/cm), Total Dissolved solids (TDS: 130 – 174 mg/l) in Manasbal Lake, the differences between the values reflect wide variation in activities prevailing in surface and subsurface environments (Amadi and Amadi, 1990).

Table1: Physio-Chemical analysis of water samples from Wular and Manasbal Lakes

S.No.	pH	TDS mg/l	EC µS/cm	Ca^{2+} mg/l	Mg^{2+} mg/l	Na^{+} mg/l	K^{+} mg/l	Cl mg/l	SO_4 mg/l	HCO_3 mg/l
WULAR										
1)	7.3	118.7	185.4688	11.3	11.4	3.4	0.3	6.4	15.9	70
2)	8.4	118.6	185.3125	14.1	10.1	2.3	0.3	5.7	16.1	70
3)	8.3	159.6	249.375	20.3	12.1	3.5	0.2	5.2	18.3	100
4)	8.9	153.5	239.8438	23.8	13.9	2.9	0.3	3.7	18.9	90

5)	7.8	155.1	242.3438	20.8	11.9	2.4	0.2	6.9	17.9	95
6)	8.5	99.88	156.0625	15.5	6.08	1.7	0.2	3.5	12.9	60
7)	8.7	128	200	21.6	6.3	2.6	0.3	6.5	10.7	80
8)	8.1	92.9	145.1563	13.7	5.4	2.5	0.1	2.9	8.3	60
9)	7.9	95.4	149.0625	17.3	3.4	2.7	0.2	4.5	7.3	60
10)	6.9	100.23	156.6094	17.23	4.5	2.4	0.2	2.5	13.4	60
11)	7.8	101.9	159.2188	17.8	3.7	3.6	0.3	3.7	12.8	60
12)	8.4	67.4	105.3125	11.4	2.4	2.8	0.2	3.2	7.4	40
13)	7.9	79.23	123.7969	15.63	3.1	1.4	0.1	5.7	13.3	40
14)	7.8	80.4	125.625	14.9	2.9	2.6	0.2	5.2	14.6	40
15)	7.6	109.1	170.4688	17.6	6.3	1.3	0.2	3.3	10.4	70
16)	8	95.8	149.6875	11.4	7.4	2.6	0.2	2.7	11.5	60
17)	8.3	117.6	183.75	16.6	7.8	1.9	0.2	1.6	9.5	80
18)	7.5	105.82	165.3438	9.22	11.1	1.5	0.2	1.4	12.4	70
19)	8.4	150.4	235	23.5	9.7	1.1	0.1	4.2	16.8	95
20)	8.1	159.4	249.0625	21.6	12.6	1.1	0.1	3.7	20.3	100

MANASBAL

S.No.	pH	TDS mg/l	EC µS/cm	Ca^{2+} mg/l	Mg^{2+} mg/l	Na^{+} mg/l	K^{+} mg/l	Cl mg/l	SO_4 mg/l	HCO_3 mg/l
1)	7.9	167.7	262.0313	19.6	10.5	7.5	1.4	7.3	1.4	120
2)	7.6	156.4	244.375	18.4	10.2	6.9	0.8	8.8	1.3	110
3)	7.4	130	203.125	11.2	10.9	5.9	1.6	7.9	2.5	90
4)	7.5	141.7	221.4063	13.4	9.7	8	1.9	6.4	2.3	100
5)	8.2	159.7	249.5313	22.6	9.8	3.7	1.1	8.7	3.8	110
6)	7.7	166	259.375	18.7	11.7	5.5	1.9	6.5	1.7	120
7)	7.5	157.2	245.625	15.6	12.2	6.1	1.8	7.4	4.1	110
8)	8.1	174	271.875	23.3	12.4	3.2	0.6	8.7	5.8	120
9)	7.9	137.3	214.5313	19.7	9.2	2.1	1.1	8.9	6.3	90
10)	8	139.13	217.3906	20.4	6.23	6.5	1.3	8.6	6.1	90
11)	7.7	161.6	252.5	17.6	10.5	8.3	1.5	7.9	5.8	110
12)	7.9	150.4	235	20.1	10.1	3.4	1.6	8.8	6.4	100
13)	7.8	162.5	253.9063	19.8	12.3	3.3	1.7	8.9	6.5	110
14)	7.9	151	235.9375	21.8	8.1	4.6	1.9	7.9	6.7	100
15)	7.9	151	235.9375	20.5	8.5	4.5	1.6	4.1	1.8	110
16)	7.8	165.8	259.0625	22.1	9.7	5.8	1.9	8.4	7.9	110
17)	7.7	133.7	208.9063	18.9	7.8	3.5	1.6	6.5	5.4	90
18)	7.8	153	239.0625	20.5	9.7	4.4	1.7	8.9	7.8	100
19)	7.5	139.2	217.5	16.7	9.7	4.6	1.9	8.8	7.5	90
20)	7.9	140.5	219.5313	19.8	8.5	3.7	1.7	8.9	7.9	90

Concentrations of some major ions Ca (11.2 - 23.3 mg/l), Mg (6.2 – 12.4 mg/l), HCO3 (90 - 120 mg/l), SO4 (1.3 – 7.9 mg/l) were recorded moderate in Manasbal Lake. However the faintly higher concentration of constituents Na (2.1 – 8.3 mg/l) and Cl (4.1 – 8.9 mg/l) in Manasbal water samples is attributed to the maximum rock water interaction as the lake is fed mainly by spring waters. Concentrations of most of the major ions were recorded moderate in Wular Lake Ca (9.2 – 23.8 mg/l), Mg (2.4 – 13.9 mg/l), Na (1.1 – 3.6 mg/l), the slightly higher concentration of chloride (Cl^-: 1.4 – 6.9 mg/l) and SO_4 (7.3 – 20.3 mg/l) in Wular reflect the impact of sewage as the Lake is fed mainly by River Jhelum which passes through the rural urban areas of valley, carries waste with it and later deposits into Wular Lake. Higher concentration of chloride in both the studied Lakes indicates high pollution level and greater rainfall.

Water types and source of solutes

Evolution of water and relationship between rock types and water composition can be evaluated by the Piper trilinear diagram **(**Piper, 1944), which is very useful in determining chemical relationships in groundwater in more definite terms than possible with other plotting methods (Walton, 1970). The piper diagram is an ingenious construction, which consists of two triangular diagrams at the lower left and lower right, describing the relative composition of cations and anions and an intervening diamond-shaped diagram that combines the composition of cations and anions. The General chemical water type identified, by the help of piper diagram (Walton 1970) (Fig.2) was $Ca^{2+} – Mg^{2+} – HCO_3$ Type and specific water types were

i) Ca-HCO3 (53%)
ii) Mg-HCO3 (33%)
iii) Hybrid water type (14%)

The general order of cations in both the studied lakes was $Ca^{2+}>Mg^{2+}>Na^+>K^+$ and the order of anions was $HCO_3>SO_4>Cl^-$. To toil the possible relation between cations and anions from both the lakes, $Ca^{2+}+Mg^{2+}$ has been plotted against HCO_3 (Fig:3&5) and HCO_3+SO_4 (Fig: 3), which indicate that Ca^{2+} and Mg^{2+} do not form bicarbonates and occur as Sulfates, indicating carbonate lithology as the main contributor of major ions, with some contribution from silicate lithology (Jeelani and Shah 2006; Sarin et al., 1984). In the plot of $Na^+ + K^+$ Vs Cl (Fig. 3) assuming that alkalies occur mainly with more Na^+ and K^+ however few samples from Manasbal lake show deviation towards $Na^+ + K^+$ indication greater contribution from silicate weathering. In the plot of TZ^+ Vs TZ^- most of the points fall on 1:1 equiline indicating a good correlation between cations and anions (balance of ions) (Fig.3).

The dominance of HCO3 in the anion budget from both the lakes is evident from the anion plot (Fig: 4a), however few samples from wular lake are showing deviation towards SO_4 end thus reflecting the effects of varying anthropogenic activities. In the cation plot (Fig.4) Ca^{2+} is showing dominance among cations, few samples from Manasbal are showing deviation from its core area towards $Na^+ + K^+$, which again reflect the effect of anthropogenic activities in the studied lakes (Javid et al; 2010).

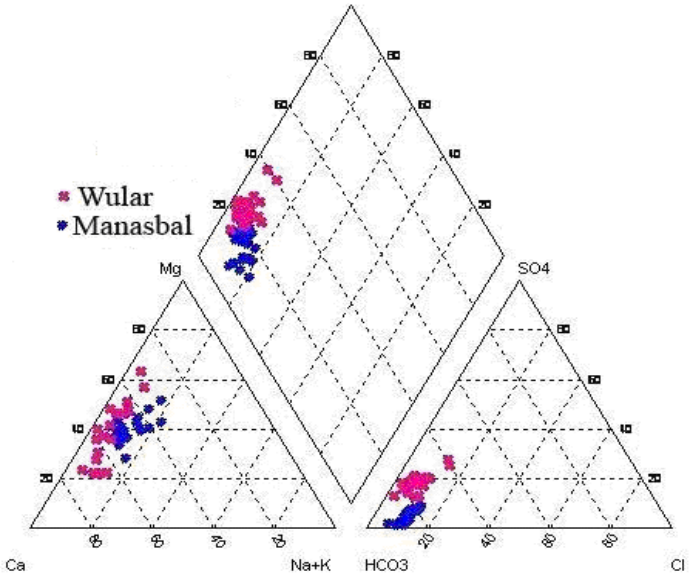


Fig.2. Piper diagram (Major ions are plotted as cations and anions % of Meq/l)

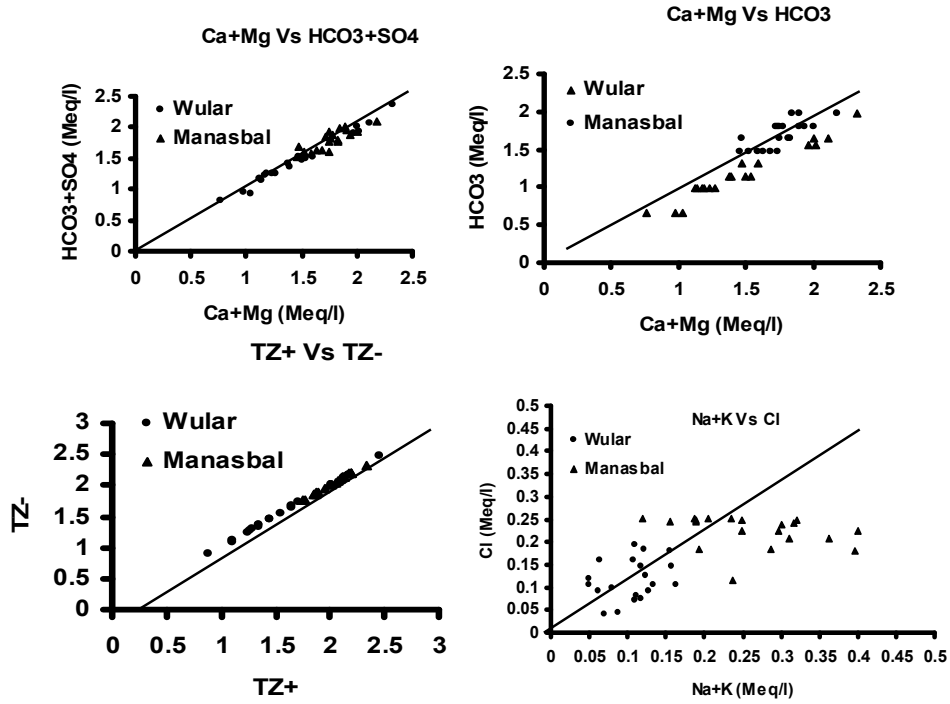


Fig. 3. Scatter diagrams between Ca+Mg Vs HCO3; Ca+Mg Vs HCO_3+SO_4; Na+K Vs Cl; TZ^+ Vs TZ^- showing possible liganding of the major ions.

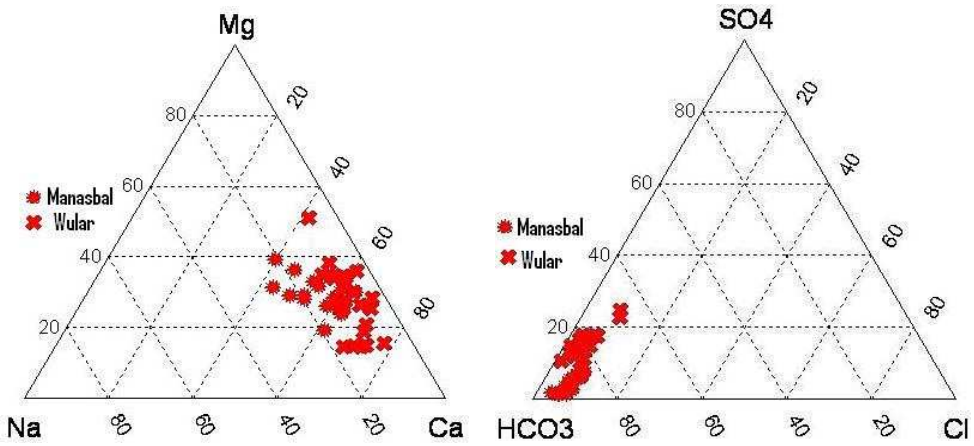


Fig. 4. (a) Ternary anion plot (b) Ternary cation plot

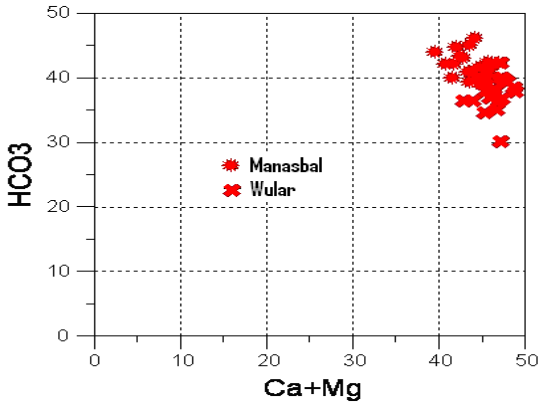


Fig.5. Langlier- Ludwig diagram.

Drinking Water Quality

Water for drinking and domestic purposes should be colorless odorless and free from turbidity. Chemical analysis of both the studied lakes suggests that all the analyzed constituents fall well within the permissible limit (Table: 2) set by W.H.O, 1984 and are hence considered safe for human consumption, however the water must be analyzed for bacteriological counts prior to its use.

Table.2: Range of chemical constituents in ground water samples and their comparison with W.H.O (1984) drinking water standards

Constituents	Minimum		Maximum		Average		Permissible limit
	Wular	Manasbal	Wular	Manasbal	Wular	Manasbal	W.H.O (1984)
pH	7.5	7.4	8.9	8.2	8.03	7.78	6.5-8.5 mg/l
TDS mg/l	67.4	130	159.6	174	114.44	151.89	1000 mg/l
E.C uS/cm	105.31	203.12	249.37	271.87	178.82	237.33	1400µmhos/cm
Ca mg/l	9.22	11.2	23.8	23.3	16.764	19.035	200 mg/l
Mg mg/l	2.4	6.23	13.9	12.4	7.604	9.8865	50 mg/l
Na mg/l	1.1	2.1	3.6	8.3	2.315	5.075	200 mg/l
K mg/l	0.1	0.6	0.3	1.9	0.205	1.53	12 mg/l
Cl mg/l	1.4	4.1	6.9	8.9	4.125	7.915	250 mg/l
HCO3 mg/l	40	90	120	120	71.5	103.5	-
SO4 mg/l	7.3	1.3	20.3	7.9	13.435	4.95	400 mg/l

CONCLUSIONS

From the forth going discussion following conclusions were drawn

i) The lake water chemistry is controlled by varied lithology and anthropogenic activities.

ii) E.C and T.D.S were recorded higher in Manasbal lake compared to Wular lake, variation reflects wide disparity in surface and sub surface environments of the lakes.

iii) Ionic concentration of few ions (Na and Cl) was recorded higher in Manasbal lake, which is attributed to maximum rock-water interaction as the lake is fed mainly by internal springs, particularly when the lime stone is dominant lithology which mostly shows dilution of ions

iv) In anion plot few samples showed deviation towards SO4 end which reflect some control of anthropogenic activities on the lake waters.

v) The waters from booth the studied lakes were within the permissible limits set by (W.H.O), however the waters must be analyzed for bacteriological counts prior to its use.

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