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Effect of *in-situ* moisture conservation practices and integrated nutrient management on nutrient availability and grain yield of *rabi* sorghum (*Sorghum bicolor*) in the Vertisols of semi-arid tropics of south India

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Received: 9 August 2000

ABSTRACT

A study was conducted during 1994–96 at Bijapur on the effect of *in-situ* moisture conservation practices and integrated use of organic and inorganic sources of nutrients on crop yield and soil properties. Compartmental bunding and ridges and furrows increased the grain yield by 22.8 and 25.6 % respectively, mainly owing to reduction in runoff, soil loss and increased availability of moisture and nutrients, viz N, P and K. Higher availability of nutrients in the top soil (0–15 cm depth) compared to sub soil (15–30 cm depth) was due to application of nutrients and higher rate of mineralisation. Among different sources of organics, application of white popinac (*Leucaena leucocephala* Lam.) proved superior over farmyard manure and vermicompost due to higher moisture conservation and faster rate of mineralisation and higher nutrient availability. Increase in N dose up to 50 kg/ha increased the availability of nutrients and their uptake resulted in improved crop growth and grain yield over 25 kg/ha and control.

Key words: compartmental bunding, ridges and furrows, runoff, soil loss, nutrients, sorghum, organics, dryland

Faulty land and crop management practices results in loss of nearly 6 000 million tonnes of top fertile soil (16 tonnes/ha) through erosion every year causing soil degradation. Soil degradation can be reduced by reducing erosion and conserving rain water through moisture conservation practices. Adoption of various *in-situ* moisture conservation measures at inter-terrace level will improve the soil moisture and nutrient status thereby stabilizing/sustaining crop yields in long run, specially during drought years. Organic residue recycling is becoming important aspect of environmentally sound sustainable agriculture. Returning residues to soil is important for maintaining soil organic matter which is further important for favourable soil structure, soil and water conservation and soil microbial and fauna activity (Unger 1978). Use of organic materials in conjunction or as alternate to chemical fertilizers is receiving attention in drylands. In view of shortage of fertilizer throughout the world particularly in India, it is estimated that fertilizer requirement will be about 24 million tonnes for achieving the food production at a level of 240 million tonnes by 2010 AD and the gap between demand and supply of fertilizer is expected to reach 9 to 10 million tonnes. The recent price hike of fertilizers coupled with low purchasing capacity of the farming community (specially in drylands) and persistent

nutrient depletion from soils have again revived the interest of organic recycling along with chemical fertilizers throughout the renewable sources of plant nutrient (organic) along with in organics and biofertilizers, so as to sustain optimum yields, maintain or improve the soil physical and chemical properties (fertility status) and provide crop nutrition package which are technically sound, economically attractive, practically feasible and environmentally safe.

To investigate the effect of *in-situ* moisture conservation practices, integrated use of organic and inorganic sources of nutrients on crop yields and soil properties, the present experiment was conducted.

MATERIALS AND METHODS

A field experiment was conducted on lands having 1.0% slope in the deep black clayey (Typic Chromusterts) soils at the Regional Research Station, Bijapur, for 2 consecutive years of 1994–95 and 1995–96 during *rabi* season to study the effect of *in-situ* moisture conservation practices and integrated nutrient management on crop yield and soil properties. The soil of experimental site had organic carbon 0.36 %, available N 128 kg/ha, available P 12.32 kg/ha, available K 333.6 kg/ha, pH 8.5 and EC 0.27 dS/m. *In-situ* moisture conservation practices, viz compartmental bunds of size 3 m × 3 m and ridges and furrows at 60 cm were formed during third week of June in 1994 and third week of May in 1995 with bund former and bullock drawn ridger

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Table 1 Grain and straw yield as influenced by *in-situ* moisture conservation practices, organics and nitrogen levels

Treatments	Grain yield (kg/ha)			Straw yield (kg/ha)		
	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled
<i>In-situ moisture conservation practices</i>						
Flat bed	1 238	1 314	1 276	1 499	1 637	1 568
Compartmental bunding	1 570	1 563	1 567	1 855	1 993	1 924
Ridges and furrows	1 658	1 547	1 603	1 999	1 902	1 950
SEM \pm	62.6	43.9	38.2	65.8	49.7	41.3
CD ($P=0.05$)	246.0	172.2	124.7	258.6	195.1	134.6
<i>Organics</i>						
Farmyard manure @ 2.5 tonnes/ha	1 486	1 457	1 472	1 796	1 850	1 823
Vermicompost @ 1.0 tonnes/ha	1 398	1 411	1 405	1 687	1 782	1 735
White popinac @ 2.5 tonnes/ha	1 582	1 557	1 570	1 870	1 900	1 885
SEM \pm	50.9	36.3	31.3	34.4	43.0	27.6
CD ($P=0.05$)	156.9	112.0	91.3	106.0	NS	80.6
<i>N-levels (kg/ha)</i>						
0	1 274	1 263	1 268	1 552	1 588	1 570
25	1 536	1 509	1 522	1 854	1 869	1 862
50	1 657	1 653	1 655	1 947	2 075	2 011
SEM \pm	37.5	52.9	24.9	36.0	37.0	25.8
CD ($P=0.05$)	108.2	95.0	69.0	103.9	106.8	71.6

respectively. White popinac (*Leucaena leucocephala* Lam.) loppings and farmyard manure were applied during third week of August and first week of September and covered manually. Vermicompost, nitrogen fertilizer as per the treatments and recommended dose of phosphorus (25 kg/ha) were applied common to all the treatments at the time of sowing. 'Maladandi M 35-1' *rabi* sorghum was sown on 4 October and 14 September to a depth of 5 cm at 15 cm apart in rows of 60 cm and harvested on 15 February 1995 and 25 January 1996 respectively.

Soil samples were collected after harvest of the crop during 1994-95 and 1995-96 respectively from 0-15 and 15-30 cm soil depths in all the replications. These samples were chemically analysed for available nitrogen content by alkaline permanganate oxidation (Subbaiah and Asija 1956), available phosphorus content by Olsen's method (Jackson 1967) and available potassium content by extracting with neutral normal ammonium acetate, photometrically (Muhr *et al.* 1965).

The experiment was laid out in split split-plot design with three replications. The main plot consisted of moisture conservation practices, viz flat bed, compartmental bunding and ridges and furrows. Subplot treatments comprised 3 sources of organics, viz farmyard manure @ 2.5 tonnes/ha, vermicompost @ 1.0 tonnes/ha and white popinac loppings @ 2.5 tonnes/ha. Three nitrogen levels, viz 0, 25 and 50 kg/ha were assigned to sub subplots.

RESULTS AND DISCUSSION

Moisture conservation practices

Compartmental bunding and ridges and furrows out-yielded the flat bed during 1994-95, 1995-96 and in the pooled analysis. In the pooled data, grain and straw yields of *rabi* sorghum increased significantly by 22.8% (1 567 and 1 924 kg/ha) with formation of compartmental bunding and further improved to 25.6 and 24.4 % (1 603 and 1 950 kg/ha) with ridges and furrows compared to flat bed (1 276 and 1 568 kg/ha respectively) (Table 1). Higher yields in the plots laid out with *in-situ* moisture conservation practices was due to conservation of rain water *in-situ* which has further led to higher moisture availability in the profile throughout the crop season. Higher yields with adoption of *in-situ* moisture conservation practices were earlier reported by More *et al.* (1996) and Velayudham *et al.* (1997).

Crop yields in drylands not only depend upon the moisture but also on the availability of nutrients in the profile. In the present investigation, compartmental bunding and ridges and furrows improved the available N, P and K over flat bed in top soil (0-15 cm) and subsoil (15-30 cm) at harvest of sorghum crop during both the years of study (Tables 2, 3 and 4). However, subsoil nutrient availability was lower than top soil probably due to lower organic matter content, whereas higher availability of nutrients in top soil was due to addition of nutrients manually. The cause for higher nutrient availability in the plots where *in-situ* moisture conservation

Table 2 Available soil nitrogen (kg/ha) at different soil depths at harvest during both the years as influenced by *in-situ* moisture conservation practices, organics and nitrogen levels

Treatments	Soil depths			
	1994-95		1995-96	
	00-15 cm	15-30 cm	0-15 cm	15-30 cm
<i>In-situ moisture conservation practices</i>				
Flat bed	127.7	119.2	139.3	129.4
Compartmental bunding	131.4	124.6	143.0	135.2
Ridges and furrows	138.6	128.1	146.7	136.5
SEm±	3.32	2.86	1.40	1.88
CD (P=0.05)	NS	NS	5.50	NS
<i>Organics</i>				
Farmyard manure @ 2.5 tonnes/ha	132.3	123.7	141.6	133.2
Vermicompost @ 1.0 tonne/ha	129.1	120.6	140.9	129.7
White popinac lopping @ 2.5 tonnes/ha	136.2	127.5	146.5	138.2
SEm±	4.19	2.71	1.46	1.87
CD (P=0.05)	NS	NS	4.50	5.76
<i>N-levels (kg/ha)</i>				
0	123.3	114.3	129.8	123.6
25	131.9	125.1	142.0	133.4
50	142.3	132.5	157.1	144.2
SEm±	2.04	2.00	2.15	1.60
CD (P=0.05)	5.89	5.77	6.20	4.62

practices were adopted was due to less loss of nutrients through runoff and soil loss and higher rate of mineralisation. Jayaram *et al.* (1982) quoted that contour cultivation alone reduced the soil loss from 12.5 to 2.0 tonnes/ha over up and down cultivation thus reducing the losses of nutrients of total nitrogen, available phosphorus and potassium and exchangeable calcium and magnesium in the Vertisols of Bellary (Karnataka). Similarly in the Vertisols of Akola, contour cultivation increased the residual nitrogen by 39 kg/ha, available phosphorus by 4.6 kg/ha and available potassium by 42 kg/ha respectively over the cultivation along the slope (Sagare *et al.* 1992).

Organics

Application of white popinac or *subabul* increased grain yield (1 570 kg/ha) significantly over farmyard manure (1 472 kg/ha) and vermicompost (1 405 kg/ha) (Table 1). White popinac application produced 11.7% higher sorghum grain yield over vermicompost. Straw yield increased significantly by 8.6% with *subabul* application (1 885 kg/ha) over vermicompost (1 735 kg/ha) and was on par with farmyard manure (1 823 kg/ha). Higher yields with *subabul* application compared to rest of the organics was reported by earlier

workers (Bellakki and Badanur 1993, Durgude and Patil 1997). The higher yields under white popinac loppings compared to farmyard manure or crop residues may be due to lower C:N ratio, faster rate of mineralisation, more moisture conservation and higher availability of N, P and K during both the years of studies in 0-15 and 15-30 cm soil depths (Tables 2,3 and 4). During second year in the top 15 cm soil depth, significantly higher available N with white popinac incorporation (146.5 kg/ha) was recorded as compared to farmyard manure (141.6 kg/ha) and vermicompost (140.9 kg/ha), with similar trend followed in subsoil. Available P and K were slightly higher with *subabul* loppings in 0-15 cm depth (30.36 and 501 kg/ha respectively) compared to vermicompost (28.97 and 483 kg/ha respectively) with similar trend observed in subsoil during second year. The above results are in conformity with findings of previous workers (Badanur and Malabasari 1995, Patil *et al.* 1996).

Nitrogen levels

Increase in N dose up to 50 kg/ha increased the grain and straw yield significantly during both the years of study and in the pooled data except, during 1994-95, whereas straw

Table 3 Available soil phosphorus (kg/ha) in 0-15 and 15-30 cm soil depths at harvest during both the years as influenced by *in-situ* moisture conservation practices, organics and nitrogen levels

Treatments	Soil depths			
	1994-95		1995-96	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
<i>In-situ moisture conservation practices</i>				
Flat bed	23.73	21.78	27.63	26.56
Compartmental bunding	26.00	23.56	30.69	29.67
Ridges and furrows	26.36	23.07	31.32	29.85
SEm±	0.68	0.56	0.58	0.48
CD (P=0.05)	NS	NS	2.28	1.89
<i>Organics</i>				
Farmyard manure @ 2.5 tonnes/ha	25.56	23.01	30.32	28.73
Vermicompost @ 1.0 tonne/ha	24.94	22.31	28.97	28.08
White popinac lopping @ 2.5 tonnes/ha	25.58	23.09	30.36	29.27
SEm±	0.38	0.58	0.51	0.74
CD (P=0.05)	NS	NS	NS	NS
<i>N-levels (kg/ha)</i>				
0	25.57	23.07	29.36	28.23
25	25.04	22.58	30.10	28.48
50	25.78	22.76	30.19	29.37
SEm±	0.60	0.55	0.48	0.65
CD (P=0.05)	NS	NS	NS	NS

Table 4 Available soil potassium (kg/ha) in 0-15 and 15-30 cm soil depths at harvest during both the years as influenced by *in-situ* moisture conservation practices, organics and nitrogen levels

Treatments	1994-95		1995-96	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
	<i>In-situ moisture conservation practices</i>			
Flat bed	434	427	476	457
Compartmental bunding	457	444	483	456
Ridges and furrows	454	440	489	472
SEm±	6.9	12.2	11.4	18.2
CD (P=0.05)	NS	NS	NS	NS
<i>Organics</i>				
Farmyard manure @ 2.5 tonnes/ha	444	432	483	459
Vermicompost @ 1.0 tonne/ha	440	420	464	448
White popinac lopping @ 2.5 tonnes/ha	462	459	501	478
SEm±	16.5	12.5	14.1	18.0
CD (P=0.05)	NS	NS	NS	NS
<i>N-levels (kg/ha)</i>				
0	410	386	434	415
25	472	462	509	489
50	464	462	505	481
SEm±	12.2	8.4	13.5	9.5
CD (P=0.05)	352	24.2	38.9	27.4

yield increased significantly only up to 25 kg N/ha. In the pooled data, application of 25 kg N/ha increased the grain yield by 20% (1 522 kg/ha) and further increase in N dose to 50 kg increased the grain yield by 31% (1 655 kg/ha) compared to control (1 268 kg/ha). Similar trend was noticed

in straw yield also. Increase in crop yield with increase in N dose up to 50 kg/ha was due to increased uptake of N, P and K which was mainly attributed to higher availability of N, P and K in 0-15 and 15-30 cm soil depths during first and second year (Tables 2,3 and 4). In the top 15 cm soil depth

during both years increase in N dose from 0 to 25 and 25 to 50 kg/ha increased the N availability significantly. Similar trend was followed in subsoil (15–30 cm depth) with lower values during first year (1994–95). Available P and K in soil was higher with 50 kg N/ha over lower doses. Higher availability of N, P and K in soil was due to higher amount of N added through fertilizer or organic sources that might have increased the nutrient status in soil in addition to the mineralisation that has occurred in soil. The above results are in conformity with findings of Surkod (1993), Mastiholi (1994) and Shelke *et al.* (1997).

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Table 3 Available soil phosphorus (kg/ha) in 0-15 and 15-30 cm soil depths at harvest during both the years as influenced by *in-situ* moisture conservation practices, organics and nitrogen levels

Treatments	Soil depths			
	1994-95		1995-96	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
<i>In-situ moisture conservation practices</i>				
Flat bed	23.73	21.78	27.63	26.56
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White popinac lopping @ 2.5 tonnes/ha	25.58	23.09	30.36	29.27
SEm±	0.38	0.58	0.51	0.74
CD (P=0.05)	NS	NS	NS	NS
<i>N-levels (kg/ha)</i>				
0	25.57	23.07	29.36	28.23
25	25.04	22.58	30.10	28.48
50	25.78	22.76	30.19	29.37
SEm±	0.60	0.55	0.48	0.65
CD (P=0.05)	NS	NS	NS	NS

Table 4 Available soil potassium (kg/ha) in 0-15 and 15-30 cm soil depths at harvest during both the years as influenced by *in-situ* moisture conservation practices, organics and nitrogen levels

Treatments	1994-95		1995-96	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
	<i>In-situ moisture conservation practices</i>			
Flat bed	434	427	476	457
Compartmental bunding	457	444	483	456
Ridges and furrows	454	440	489	472
SEm±	6.9	12.2	11.4	18.2
CD (P=0.05)	NS	NS	NS	NS
<i>Organics</i>				
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25	472	462	509	489
50	464	462	505	481
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CD (P=0.05)	352	24.2	38.9	27.4

yield increased significantly only up to 25 kg N/ha. In the pooled data, application of 25 kg N/ha increased the grain yield by 20% (1 522 kg/ha) and further increase in N dose to 50 kg increased the grain yield by 31% (1 655 kg/ha) compared to control (1 268 kg/ha). Similar trend was noticed

in straw yield also. Increase in crop yield with increase in N dose up to 50 kg/ha was due to increased uptake of N, P and K which was mainly attributed to higher availability of N, P and K in 0-15 and 15-30 cm soil depths during first and second year (Tables 2,3 and 4). In the top 15 cm soil depth

during both years increase in N dose from 0 to 25 and 25 to 50 kg/ha increased the N availability significantly. Similar trend was followed in subsoil (15–30 cm depth) with lower values during first year (1994–95). Available P and K in soil was higher with 50 kg N/ha over lower doses. Higher availability of N, P and K in soil was due to higher amount of N added through fertilizer or organic sources that might have increased the nutrient status in soil in addition to the mineralisation that has occurred in soil. The above results are in conformity with findings of Surkod (1993), Mastiholi (1994) and Shelke *et al.* (1997).

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Response of 'Mosambi' sweet orange (*Citrus sinensis*) to degreening, mechanical waxing, packaging and ambient storage conditions

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ABSTRACT

Response of 'Mosambi' sweet orange (*Citrus sinensis* Osbeck) fruits to degreening by ethylene in continuous flow process, mechanical waxing, packing in vented polyethylene and ambient storage conditions (25±5°C; 60–70% RH) was studied. Three pre-harvest sprays of carbendazim (500 ppm) were applied to fruits at 15 days interval. Respiration rate increased with ethylene treatment during degreening for 48 hr and then decreased gradually. Ethylene treated fruits turned yellow in colour within 48 hr while non-treated fruits remained green during that period. Weight loss in 'Mosambi' fruit was 8.89–10.05% in Sta-fresh 451 wax coating compared with 2.93% in polyethylene liner packing while wax coated fruit packed in polyethylene liner lost 2.03–2.29% of their weight after 30 days. Decay was maximum (22.01%) after 30 days in non-waxed fruit packed in vented polyethylene as compared with control (1.15%). Decay was mainly due to sour rot incited by *Geotrichum candidum*. Stem-end rots and *Penicillium* rots were not observed. There was no decay in fungicidal wax (Sta-fresh 451+1 000 ppm thiabendazole) coated fruit packed in polyethylene liner. Wax coating reduced respiration rate of 'Mosambi' fruits. Change of colour from green to yellow was quite slow in wax coated fruit as compared to non-coated fruit. After 30 days, yellow colour intensity was more in degreened + non-waxed fruit as compared with non-degreened + non-waxed fruit. Fruits packed without polyethylene liner lost more juice and ascorbic acid and had more firmness, TSS and acidity content. Appearance and flavour score was highest after 30 days in degreened fruit treated with Sta-fresh 451 wax (full strength or 1:1 dilution) and packed in vented polyethylene lined CFB boxes.

Key words: 'Mosambi' sweet orange, degreening, wax coating, polyethylene liner, storage, quality, respiration

Sweet orange crop occupies 110 000 ha area in the country with 893 000 tonnes of annual production (NH 1994). 'Mosambi' is an important cultivar of sweet orange (*Citrus sinensis* Osbeck) particularly in Maharashtra and other states such as Andhra Pradesh, Madhya Pradesh, Rajasthan and Punjab. In Maharashtra alone, annual production of Mosambi sweet orange is 150 000 tonnes. In tropical climate of Central and South India, sweet orange fruits do not develop desired colour at maturity. Consumers prefer yellow or yellow-orange fruits of sweet orange as compared with green fruits. Degreening by dipping of fruit in ethrel (1 000–3 000 ppm) solution has been tried with colour development in 5–6 days (Purandhare *et al.* 1992). Dipping results in uneven colour development with higher waterloss from fruit and contamination of healthy fruit by pathogens. In the process of degreening with ethylene gas many of these problems can be overcome (Ladaniya 1999).

Manual wax coating by dipping 'Mosambi' fruit in 3–9% aqueous wax has been tried (Ghosh and Sen 1984).

Polyethylene film bags of 100–200 gauge with 0.2–0.4% ventilation have reduced waterloss while fungicides such as benomyl (Benlate) and carbendazim effectively controlled rots (Kumbhare and Chaudhari 1979). The pre-harvest sprays of carbendazim significantly reduced decay incidence particularly in degreened mandarins (Ladaniya and Singh 1998). In mechanically waxed fruit, drying of wax coating was quicker with less rotting during storage (Ladaniya and Dass 1994).

The present investigation was undertaken to evaluate physiological and physico-chemical quality response of 'Mosambi' sweet orange to degreening by ethylene gas, mechanical wax coating and packing in polyethylene lined container under ambient storage conditions.

MATERIALS AND METHODS

In 'Ambia' (Spring blossom) season during 1998, three pre-harvest sprays of carbendazim (500 ppm) were applied to uniformly growing 'Mosambi' sweet orange trees at the interval of 15 days. Harvested fruits were divided into two lots; one lot was subjected to degreening for 48 hr with ethylene gas (5–10 ppm) through continuous flow process at

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Table 1 Per cent weight loss and decay in 'Mosambi' as affected by degreening, waxing and packing in polyethylene liner

Treatments	Weight loss (%)		Decay (%)	
	15 days	30 days	15 days	30 days
Degreening+Sta-fresh-451+vented PE	1.06	2.29	0.00	0.00
Degreening+Sta-fresh-451(1:1)+ vented PE	0.98	2.03	0.00	0.00
Degreening + vented PE	1.18	3.23	0.00	3.42
Vented PE liner	0.81	2.93	7.88	22.01
Degreening	4.19	10.35	0.00	0.00
Sta-fresh-451	3.55	8.89	0.00	1.26
Sta-fresh-451 (1:1)	3.47	10.05	1.41	1.14
Control	7.34	14.62	1.79	1.15
SE for means \pm	0.80	0.70	1.20	4.39
P = 0.05	1.72	2.16	3.65	13.37

PE, Polyethylene; *Days, days in storage

27–29°C temperature and 90–95% relative humidity (Ladaniya 1999). Other lot of fruit was kept untreated (non-degreened) at the same temperature and relative humidity but without ethylene.

Fruits from both the lots were sorted on roller conveyer, washed with chlorinated water (1 000 ppm chlorine @1.5 water/min) spray on soft nylon roller brushes. After rinsing with fresh (chlorine free) water (8 min) excess water on fruit surface was removed on sponge rollers. The total wash time on nylon rollers was 40 sec with nearly 105 rpm speed. Wax coating was applied through traversing atomized sprayer (14 ml/min spray discharge) on horse-hair roller brushes. The Sta-fresh-451 (resin based high gloss aqueous wax coating with 15.9% solids) containing a fungicide 2-(4-thiazolyl) benzimidazole (TBZ 0.1%) was applied at the rate of 844 ml wax/hr/1000 kg fruit. The surface dried and size graded fruits of nearly 7.5 cm diameter were taken for storage study. For lining of vented corrugated fibre board (CFB) boxes measuring 30 cm (L) \times 23 cm (W) \times 15 cm (H), 50 mm thick polyethylene (PE) with 0.5% vented area was placed before packing fruit. The treatments were - T₁, Degreening + Sta-fresh (451) + PE liner in box; T₂, degreening + Sta-fresh (451)@ 1:1 dilution with soft water + PE liner in box; T₃, degreening + PE liner in box (no waxing); T₄, PE liner in box (no degreening and no waxing); T₅, degreening (no waxing and no PE liner in box); T₆, Sta-fresh (451) (no degreening

and no PE liner in box); T₇, Sta-fresh (451) @ 1:1 dilution (no degreening and no PE liner in box) and T₈, control (no degreening, no waxing and no PE liner in box).

The treatments were replicated thrice; each replication with 24 fruits. Fruits were stored under ambient conditions (25 \pm 5°C; 60–70% relative humidity) and analysed after 15 and 30 days.

Ten fruits (with three replicates) were analysed for firmness, juice content, TSS acidity and ascorbic acid content. Firmness was measured with the help of hand held pressure tester (Effigy model 011) until peel is punctured with round plunger (8 mm diameter). Total soluble solids were measured with a hand refractometer whereas titratable acidity and ascorbic acid contents were measured by titrimetric methods (Ranganna 1986). Rind colour was recorded at the beginning of degreening process and after 24 and 48 hr in ethylene treated and non-treated fruit. Similarly during storage study colour of six fruits was recorded at each interval with colour difference meter (Gardener color gard systems 1000/05 Pacific scientific, USA) for tristimulus of L*, a* and b*. The measurements were according to CIE (Commission Internationals and Eclairage) system as 'L*' (Lightness or darkness; 0, black; 100, white), 'a*' (bluish-green/ red purple hue component, '-a*' indicates bluish green while + a* indicates red) and 'b*' (yellow / blue hue component '-b*' indicates blue while '+ b*' indicates yellow). The respiration

Table 2 Colour changes due to ethylene treatment during degreening of Mosambi orange fruits

Time	Under ethylene treatment			Without ethylene		
	L*	a*	b*	L*	a*	b*
0 hr	62.51	-16.49	42.50	60.96	-15.69	35.48
24 hr	68.26	-6.29	50.69	63.28	-14.13	40.91
48 hr	76.50	1.86	53.53	67.96	-12.94	47.61

L indicates lightness from white = 100 to black = 0; - a* indicates greener fruit, + a* indicates orange colour, - b* indicates blue, + b* indicates yellow colour

All colour values are average of 18 fruits

Table 3 Effect of degreening, waxing and packing in polyethylene liner on colour of 'Mosambi' sweet orange

Treatments	Colour values							
	After 15 days				After 30 days			
	L*	a*	b*	a/b	L*	a*	b*	a/b
Degreening + sta- fresh 451 + vented PE	(84.26)	(3.55)	(64.87)	(0.055)	(81.70)	(1.86)	(62.79)	(0.028)
	82.56	3.91	63.79	0.061	82.16	2.95	62.80	0.047
Degreening + sta -fresh 451 (1:1) + vented PE	(81.97)	(3.14)	(64.55)	(0.049)	(79.02)	(2.89)	(59.50)	(0.048)
	79.73	4.38	64.20	0.068	81.64	4.09	64.52	0.063
Degreening + vented PE	(77.57)	(4.55)	(65.51)	(0.069)	(79.09)	(6.22)	(65.52)	(0.095)
	76.19	5.55	66.50	0.083	78.28	10.18	69.29	0.147
Vented PE	(72.85)	(-4.22)	(58.15)	(-0.072)	(72.68)	(-2.57)	(57.44)	(-0.044)
	74.09	3.99	62.65	0.064	75.48	8.44	62.01	0.136
Degreening	(81.19)	(2.36)	(53.53)	(0.054)	(77.11)	(2.16)	(60.58)	(0.036)
	80.12	4.24	67.12	0.063	77.08	7.83	65.16	0.120
Sta-fresh 451	(79.25)	(-1.93)	(61.05)	(-0.031)	(79.04)	(-7.44)	(54.99)	(-0.135)
	76.83	-0.19	60.65	-0.003	79.55	-4.93	56.32	-0.088
Sta-fresh 451 (1:1)	(71.39)	(-11.82)	(49.05)	(-0.240)	(74.85)	(-4.53)	(57.75)	(-0.080)
	70.28	-10.26	49.28	-0.208	75.01	6.05	64.21	0.094
Control	(73.63)	(-3.67)	(59.20)	(-0.062)	(79.83)	(-0.89)	(65.30)	(-0.014)
	73.80	0.40	62.33	0.006	78.16	11.12	68.73	0.162

L indicates lightness from white = 100 to black = 0; - a* indicates greener fruit, + a* indicates orange colour, - b* indicates blue, + * indicates yellow colour; a/b ratio indicates intensity of yellowish - green or yellow-red (orange) colour. Values in parentheses indicate initial values (at 0 days or beginning of storage); PE= polyethylene. All colour values are average of 6 fruits

rate was measured with Infrared CO₂ analyzer (Amtek model CD-3A) initially and during storage for 15 and 30 days. Respiration was also measured before, during and after degreening up to 30 days to find response of 'Mosambi' orange to ethylene treatment in separately stored fruit. The fruit appearance and flavour were evaluated in a preference test by the trained 15 member preference panel (Heintz and Kader 1983) using 9 point hedonic scale.

The per cent weight loss and extent of decay were recorded during storage and decay causing organisms were identified.

Treatments were organized in a completely randomized design and data were subjected to analysis of variance ($P=0.05$).

RESULTS AND DISCUSSION

Weight loss and decay

Sta-fresh (451) wax coating reduced loss in fruit weight significantly as compared with non-coated fruit (control). Weight loss of waxed fruit was further reduced with polyethylene lining in the CFB box (Table 1). In non-waxed fruit weight loss was significantly less (3.23 and 2.93%) with polyethylene liner in box (T₃ and T₄) as

compared to waxing (8.87 and 10 .05%) without polyethylene liner (T₆ and T₇). These studies indicated that polyethylene liner is must in packing for significant reduction in weight loss. Among all the treatments, weight loss was highest (14.62%) in control (T₈) followed by 10.35% in degreened fruit packed without polyethylene (T₅) suggesting that ethylene treatment did not have any hastening effect on water loss. In degreened fruit packed in polyethylene (T₃) weight loss was 3.23% and in non-degreened fruit packed in polyethylene liner (T₄) weight loss was 2.93% after 30 days indicating that higher relative humidity has very pronounced effect in checking water loss of fruit. Waxed fruits packed without polyethylene had 8.89 and 10.05% weight loss with appearance score 7.19 and 3.55, respectively (Table 5) after 30 days suggesting that 8.89 or 9% weight loss is a critical limit beyond which fruit acceptability declines sharply. All the treatments which had weight loss more than 8.89 have scored less than 5 on appearance scale indicating non-acceptability. Coating with diluted wax (1:1) and packing without polyethylene resulted in 10.05% weight loss (T₇) indicating that this treatment could not check water loss. However, full strength wax was more

Table 4 Physico-chemical characteristics of 'Mosambi' fruits as influenced by various treatments during storage

Treatments	Firmness (kg)			Juice content (%)			TSS (%)			Titrateable acidity (%)			Ascorbic acid (mg/100 ml)		
	Days in storage			Days in storage			Days in storage			Days in storage			Days in storage		
	0	15	30	0	15	30	0	15	30	0	15	30	0	15	30
Degreening+sta-fresh-451+vented PE	9.80	9.85	9.65	43.41	42.11	39.69	10.17	9.56	9.00	0.27	0.29	0.26	40.27	38.07	35.38
Degreening+Sta-fresh-451(1:1)+vented PE	9.93	9.93	9.61	43.75	42.01	39.47	10.20	10.13	9.20	0.27	0.26	0.24	40.97	40.28	33.79
Degreening+vented PE	9.47	9.45	9.77	43.28	42.72	39.16	9.92	10.33	9.73	0.27	0.30	0.21	41.67	38.30	32.78
Vented PE liner	9.68	9.73	9.73	42.87	43.37	40.17	9.80	10.10	9.67	0.29	0.30	0.22	42.00	38.22	35.06
Degreening	9.35	9.30	10.55	42.66	42.94	36.57	9.93	9.93	9.20	0.28	0.28	0.29	42.00	33.34	30.90
Sta-fresh-451	9.30	9.80	9.85	42.80	43.42	40.46	9.73	9.47	9.27	0.29	0.29	0.25	41.94	38.99	35.70
Sta-fresh-451 (1:1)	9.80	9.92	9.93	44.09	40.91	39.33	9.70	9.47	9.40	0.29	0.30	0.30	42.00	36.01	35.86
Control	10.03	9.35	10.38	41.88	39.86	35.56	9.77	10.07	10.40	0.30	0.30	0.29	42.30	34.27	31.04
SE for means ±	0.45	0.47	0.17	0.50	1.14	0.69	0.07	0.31	0.24	0.007	0.001	0.02	0.51	0.55	0.87
P = 0.05	NS	NS	0.53	NS	NS	2.11	0.21	NS	0.73	0.01	NS	0.05	NS	1.67	2.67

PE, Polyethylene

effective with lower (8.89%) weight loss. Aworh *et al.* (1991) reported that oranges waxed with commercial wax preparation 'Shield Brite A 40' lost 13.8% weight as compared to 20.8% in control at 21-31°C and 71-90% RH during 31 days' storage. Weight loss in waxed fruit varies depending on type of wax and its concentration used.

After 15 days, decay losses were significantly less in all the treatments except polyethylene liner (7.88 %) without degreening and waxing (T₄). The losses were mainly due to sour rot caused by *Geotrichum candidum*. The stem-end rot due to *Diplodia natalensis* and *Penicillium* rots were not noticed probably due to pre-harvest carbendazim and post-harvest thiabendazole treatments. Carbendazim and thiabendazole were found to be ineffective against *Geotrichum candidum* (Eckert and Brown 1986). With extension of storage up to 30 days, losses increased from 7.88 to 22.01% in fruit under T₄. Polyethylene liner although vented (0.5%) increased humidity beyond 95% around the fruit. High humidity coupled with ambient temperatures (25-30°C) resulted in higher decay losses, as the fruits were not washed and treated with fungicidal wax. These findings indicated that washing with chlorinated water and post-harvest fungicide treatment is necessary if fruits are packed in vented polyethylene lined CFB box. Washing with chlorinated water probably removed considerable load of *Geotrichum candidum* thereby reducing rotting in waxed fruit (T₁, T₂, T₆ and T₇). Chlorine in the water (in the form of hypochlorous acid) effectively controls rots due to *Penicillium* spp. The spores of *Geotrichum candidum* were killed in chlorinated water (Brown and Wardowski 1984). In degreened but non-waxed fruit (T₃), polyethylene liner resulted in 3.42% decay. Lower decay in this treatment could possibly be attributed to ethylene induced activities of enzymes particularly phenyl ammonia-lyase (PAL). Kuc (1982) reported that PAL catalyses the branch-point step reactions of the shikimic acid pathway leading to the biosynthesis of phenols, phytoalexins and lignins, which are associated with induced resistance to diseases. The level of resistance to *Geotrichum candidum* has been found to be parallel to the amount of lignin-like deposition (Baudoin and Eckert 1985). After 30 days, there was no decay (0.00%) in degreened fruit packed without polyethylene (T₅) followed by non-degreened control (1.15% decay) with non-significant difference. Lower decay losses in these treatments were probably due to shrivelling and toughening of peel and lower humidity around the fruit. Fungal pathogens are more active when the host has required moisture content with higher surrounding humidity.

Respiration rate during and after degreening

Respiration rate of 'Mosambi' sweet orange increased greatly during degreening with ethylene (5-10 ppm). CO₂ evolution peaked its highest (80 mg/kg.hr) after 48 hr. After removal of fruit from degreening chamber, respiration rate declined in 4-5 days. In non-

Table 5 Effect of degreening, waxing and polyethylene liner packing on 'Mosambi' fruit flavour and appearance in storage

Treatments	Flavour (scale 1-9)		Appearance (scale 1-9)	
	Days in storage		Days in storage	
	15	30	15	30
Degreening+Sta-fresh-451+vented PE	8.66	7.66	9.00	8.60
Degreening+Sta-fresh-451(1:1)+ vented PE	8.64	7.69	8.94	8.84
Degreening + vented PE	7.48	7.10	7.43	6.12
Vented PE liner	7.22	6.65	7.26	6.16
Degreening	6.63	5.57	5.65	4.11
Sta-fresh-451	7.27	6.27	8.19	7.19
Sta-fresh-451(1:1)	6.52	5.28	6.25	3.55
Control	6.55	5.77	5.45	3.64
SE for means \pm	0.19	0.24	0.17	0.14
P = 0.05	0.61	0.74	0.54	0.45

Hedonic scale (1-9) = 1, dislike extremely; 2, dislike highly; 3, dislike moderately; 4, dislike slightly; 5, neither like nor dislike; 6, like slightly; 7, like moderately; 8, like highly; 9, like extremely.

PE, Polyethylene

treated fruits, respiration was unaltered and declined gradually. Results indicated that in non-climacteric fruit like sweet orange, respiration shoots up with exposure to ethylene and comes to normal after removal of fruit from ethylene atmosphere. Ethylene treatment had no adverse degradative effect on physico-chemical attributes in non-climacteric Mosambi orange except change of rind colour and slight drop in acidity accompanied by temporary rise in respiration rate.

Respiration during storage

The respiration rate was reduced by nearly 30% in Sta-fresh (451) full strength (15.9% solids) wax coated fruit as compared with non-waxed (control) fruit. Diluted wax (1:1) with 7.9 % solids also reduced the respiration. Wax solids coated on the fruit surface reduce normal gas exchange through the rind and thereby reduce respiration rate; higher the solids in wax emulsion, more the reduction in respiration rate. The data on per cent weight loss also corroborated with these results. The dilution has advantage of reducing cost of wax. Respiration rate of fruits under all the treatments declined with advancement of storage period. In degreened but non-waxed fruit (T_3 and T_4), respiration rate remained higher after 15 and 30 days in storage. Fruits packed in polyethylene lined boxes (T_4) had lower respiration rate as compared with control.

Fruit colour

Colour changed within 48 hr from green to yellow in degreened fruit while fruit without ethylene treatment remained green as evident from $+a^*$ value (+1.86) in ethylene treated fruit as against $-a^*$ (-12.94) in untreated fruit (Table 2). The difference in rind colour of degreened (T_1 , T_2 , T_3 and T_4) and non-degreened (T_5 , T_6 , T_7 and T_8) fruit is evident from $+a^*$ and $-a^*$ values, respectively, at the beginning of

storage (see values given in parentheses in Table 3). Fruit colour changed from green to yellow in non-degreened and non-waxed fruit during ambient storage but very slow and it took 15 days. The $-a^*$ turned positive during a span of 15 days in control (T_5) and non-waxed + non-degreened fruit packed in vented polyethylene liner (T_4). In non-degreened and waxed fruit (T_6 and T_7), the $-a^*$ value reduced to some extent but did not change to $+a^*$ after 15 days. The loss of chlorophyll as evident from reduction in $-a^*$ value continued relatively more rapidly in fruit waxed with diluted wax (1:1). Fruit coated with undiluted wax (T_8) were green with $-a^*$ value even after 30 days indicating that wax coating slowed down colour change. Lower oxygen level and increased CO_2 inside the fruits have been reported to slow down degreening in non-ethylene exposed but waxed 'Fallglo' tangerine (*Citrus* hybrid) although internal ethylene levels were higher (Petraček and Montalvo 1997). In degreened fruit (T_3), $+a^*$ value increased along with increase in b^* after 15 and 30 days resulting in intense yellow colour. After 30 days, L^* value was maximum in waxed fruits packed in polyethylene liner (T_1 and T_2) indicating better sheen and luminance of colour.

Physico-chemical and organoleptic attributes

There was no difference in firmness of fruit under various treatments at the beginning of storage (0 days) and after 15 days indicating degreening had no softening effect on sweet orange rind (Table 4). After 30 days, firmness was significantly higher in control (T_5) and degreened+ non-waxed fruit packed without polyethylene liner (T_4) which could probably be attributed to excessive shrivelling and toughening of rind. Natural firmness of the sweet orange rind was retained due to polyethylene liner in the box. There was non-significant difference in juice percentage of fruit under various treatments at beginning of storage. After 15 days,

juice content did not vary significantly but declined after 30 days; untreated control fruit having least (35.56%) juice content. Waxing and packing in polyethylene lined boxes helped in retention of higher juice content. Total soluble solids (TSS) were comparatively higher in fruit subjected to degreening at 0 days although trend was not clear in degreened and non-degreened fruit. Higher TSS content in control was attributed to concentration effect due to water loss. Acidity decreased by ethylene treatment as evident in degreened fruit at the beginning of storage, however, this difference became non-significant after 15 days due to inconsistent changes. After 30 days acidity content declined in most of the treatments. Higher acidity content in fruits packed without polyethylene liner particularly under T_5 , T_7 and T_8 was attributed to rapid water loss and concentration effect. The ascorbic acid content declined during storage but waxing and packing in polyethylene liner minimized the loss.

After 15 days, fruit flavour was significantly higher and very much acceptable (score 8.64–8.66) in degreened and waxed fruit (T_1 and T_2) packed in polyethylene liner (Table 5). As the storage period extended up to 30 days, flavour score declined; lowest being in control (T_0) and degreened fruit packed without polyethylene liner (T_3). Degreened and waxed fruit packed in polyethylene liner had highest score of flavour (7.66–7.69) after 30 days. Hagenmaier and Baker (1993) reported that CO_2 exchange across the citrus fruit rind was affected depending on type of wax used. The shellac coatings were found to affect fruit flavour as compared to polyethylene, resin and carnauba waxes.

Appearance of degreened + waxed (Sta-fresh 451) + polyethylene liner- packed fruit (T_1 and T_2) was the best after 15 and 30 days in storage as compared with rest of the treatments. Waxed fruits (non-diluted Sta-fresh 451) packed without polyethylene liner (T_6) also had higher score (7.19–8.19) after 15 and 30 days due to turgidity and freshness although yellow colour development was slow. Non-waxed fruits packed in polyethylene liner (T_3 and T_4) also had attractive appearance up to 15 days but fruits appeared lacklustre after 30 days.

It was concluded that degreening with ethylene gas followed by waxing (Sta-fresh 451 wax non-diluted and diluted @ 1:1 ratio) and packing in vented polyethylene liner in the CFB box can retain freshness of 'Mosambi' sweet orange fruits without affecting flavour up to 30 days at $25 \pm 5^\circ C$ and 60–70 % relative humidity. Degreening with ethylene gas (5–10 ppm) produced attractive yellow colour within 48 hr. Polyethylene liner alone was more effective in controlling water loss than wax coating alone, however, polyethylene liner (vented) without post-harvest wash (using chlorinated water) and fungicidal treatment resulted in higher decay.

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Ecological studies and management of *Vanessa cashmirensis* on hop (*Humulus lupulus*) in dry temperate Himachal Himalayas

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ABSTRACT

Vanessa cashmirensis Kollar (Nymphalidae: Lepidoptera) completes two-three overlapping generations annually during April-September in the Lahaul valley of Himachal Pradesh. But the second occurring during mid-June to July causes devastating damage to hop (*Humulus lupulus* L.) plantations. The peak of the pest activity occurred between the end of June and first week of July with the population of 59.3-90.4 larvae/ vine during 1995-97. The population of *V. cashmirensis* was curtailed by predacious spiders, wasp and a larval-pupal ichneumonid parasitoid. *V. cashmirensis* completed the life cycle from egg to adult emergence in 37-44 days at 25°C. Persistent toxicity of six insecticides tested at three concentrations each against third instar caterpillars revealed that carbaryl (0.1 and 0.2%), cypermethrin (0.0075 and 0.015%), chlorpyrifos (0.04 and 0.08%) and deltamethrin (0.0025 and 0.005%) remained effective and superior to others even up to 21 days of application except the deltamethrin which lost its effectiveness after 15 days.

Key words: *Vanessa cashmirensis*, *Humulus lupulus*, seasonal abundance, management

Hop (*Humulus lupulus* L.) of Cannabinaceae family is an aromatic plant, owing to stringent latitudinal and temporal requirements, is adapted to the dry temperate regions of north-western Himalayas. But its production is curtailed by various insect-pests at different growth stages of the crop (Jotshi 1993, Sood *et al.* 1999). The black caterpillar, *Vanessa cashmirensis* Kollar (Nymphalidae: Lepidoptera) is the key pest. It remains associated with hop from the emergence of vine to the time of picking of cones, inflicting considerable losses. Literature revealed scanty information about the life processes of this pest, therefore, a study was planned to gather information on biology, dynamics and to evolve suitable management tactics for this pest.

MATERIALS AND METHODS

Observations on bio-ecology and management of *Vanessa cashmirensis* was made for three years during 1995-97 at the Regional Research Station, Kukumseri, Lahaul (2 672 above mean sea-level) representing the dry temperate region of Himachal Pradesh.

Biological observations

The freshly laid egg masses from the hop plantation were brought to laboratory and kept in petri-plates for hatching in

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the BOD incubator at 25±1°C. The first three larval instars were reared there and fed with tender leaves of hop which were changed on alternate day. Thereafter, they were shifted to glass chimneys for further rearing. Observations on development and survival were recorded daily to work out incubation, larval- and pupal period and the adult longevity.

Population dynamics

Observations on seasonal abundance of black caterpillars were made at weekly intervals from the day of their first appearance in the field. The incidence was recorded on 20 randomly selected hop vines, however to work out the level of infestation 100 vines were observed. These observations were used to calculate the infestation index as per Sood and Bhalla (1996).

For recording the parasitoids and the extent of parasitization eggs, larvae and pupae were collected from the field at weekly interval and reared in the laboratory. Mortality due to parasitoids was calculated as suggested by Root and Skelsey (1969). Predators associated with different stages were observed in the field directly.

Evaluation of insecticides

A field-cum-laboratory experiment was conducted to evaluate six insecticides, viz carbaryl (0.05, 0.1 and 0.2%), chlorpyrifos (0.02, 0.04 and 0.08%), cypermethrin (0.0037, 0.0075 and 0.015%), deltamethrin 0.00125, 0.0025 and

Table 1 Developmental biology of *Vanessa cashmirensis* at 25 (± 1)°C

Developmental stage	Mean value (\pm SE)	Range value
<i>Egg</i>		
Duration (days)	7.7 \pm 0.59	7-9
Hatchability (%)	96.6 \pm 1.50	94.0-100.0
Cluster size (numbers)*	153.5 \pm 26.25	80-200
<i>Larva</i>		
Duration (days)		
I	5.1 \pm 0.63	4-6
II	5.2 \pm 0.57	4-6
III	4.0 \pm 0.59	3-5
IV	3.6 \pm 0.60	3-5
V	7.6 \pm 0.77	6-9
Total duration (days)	25.2 \pm 1.43	22-27
Survival (%)	89.5 \pm 2.45	84.0-95.8
<i>Pupa</i>		
Duration (days)	8.2 \pm 0.45	7-9
Survival (%)	98.4 \pm 1.38	95.2-100.0
Total developmental period (days)	40.1 \pm 1.48	37-44
<i>Adult</i>		
Emergence (%)	84.8 \pm 2.47	80-92
Longevity (days)**		
Male	8.9 \pm 1.15	7-11
Female	10.0 \pm 1.27	8-13

*Observed from the field collected eggs

**Room temperature varying between 18 and 26°C

0.005%), endosulfan (0.0175, 0.035 and 0.07%) and malathion (0.025, 0.05 and 0.1%) against the third instar caterpillars of *V. cashmirensis*. Four year old hop vines cv Late Cluster (n=10) were sprayed with the insecticides at desired concentration in the last week of June with a foot sprayer. The treated leaves plucked from different heights were kept in petri-plates and brought to the laboratory at regular interval. The third instar caterpillars starved for 12 hr (n=20) were exposed to the treated leaves at 1,8,15 and 21 days after treatment, replicating thrice. Observations on the mortality were recorded after 24 hr. The data on mortality were corrected following Abbott (1925). The residual toxicity of the insecticides was compared on the basis of persistent toxicity index as suggested by Pradhan and Venkataraman (1962).

RESULTS AND DISCUSSION

Biology

The females deposited elongated, light-gray eggs in clusters (80-200/ cluster) in two-three overlapping layers, average number of eggs in a cluster being 153. The incubation period ranged between 7-9 days (mean 7.7 days) with 96.6% hatchability (Table 1). There were five larval instars, the duration of which ranged from 22-27 days (mean: 25.2 days) with 10.5% mortality occurring in the larval stages. The pupal period ranged between 7-9 days and suffered mortality to a limited extent only (1.6%) (Table 1). The life cycle was completed in 40 days (range : 37-44 days) and the survival

to adult stage was 84.8%.

The females slightly out numbered the males resulting in a sex ratio of 1.04 :1 (n=850). The adults lived for 7-13 days at room temperature (the ambient temperature varying between 18-23°C) with females surviving for longer period (10.0 days) than the males (8.9 days). However, in captivity the mating and oviposition did not occur.

Nature of damage

The eggs are laid on the under surface of leaves, of the egg clusters observed (n=325), 89% eggs deposited at lower portion of the vine (150 cm or less). The caterpillars fed gregariously by scrapping the leaves nearby the place of egg deposition up to third instar. Thereafter, the caterpillars ascend and fed singly in small groups and skeletonize the leaves. In case of severe infestation whole of the vine is defoliated and no cone formation was observed.

Seasonal incidence

V. cashmirensis completed two to three overlapping generations depending upon the prevailing weather conditions from April-May to September in the dry-temperate Himalayas. The second generation occurring during mid June-July/August inflicted damage to hop plantations whereas the remaining two were completed mainly on the weed host, stinging nettle, *Urtica dioica* which seems to be its primary wild host and later shifts to hop. Bryant *et al.* (1997) reported similar occurrence of a closely related species *Vanessa atlanta*

Table 2 Persistent toxicity of some insecticides to *V. cashmirensis* caterpillars on hop (pooled for 1995-97)

Treatment	Concentration (%)	Mortality (%) days after treatment				Period up to which mortality occurred (days)	Mean per cent mortality	Persistent toxicity
		1	8	15	21			
						P	T	PT
Carbaryl	0.2	100.0 (10.05)	97.1 (9.90)	82.9 (9.14)	51.7 (7.18)	21	82.9	1741.2
	0.1	100.0 (10.05)	71.7 (8.51)	48.7 (7.01)	21.3 (4.62)	21	60.3	1266.5
	0.05	100.0 (10.05)	60.0 (7.78)	35.1 (5.73)	7.9 (2.34)	21	50.6	1062.3
Chlorpyrifos	0.08	100.0 (10.05)	72.9 (8.59)	68.7 (7.52)	45.0 (5.32)	21	71.5	1502.3
	0.04	100.0 (10.05)	60.5 (7.80)	49.5 (6.32)	25.0 (3.20)	21	58.6	1230.4
	0.02	100.0 (10.05)	49.2 (7.02)	32.9 (5.02)	8.7 (1.19)	21	47.5	997.3
Cypermethrin	0.015	100.0 (10.05)	97.5 (9.93)	77.9 (8.86)	55.0 (7.38)	21	82.6	1734.4
	0.0075	100.0 (10.05)	88.7 (9.47)	52.9 (7.28)	32.5 (5.73)	21	68.5	1438.1
	0.0037	98.6 (9.99)	77.9 (8.86)	36.2 (6.04)	12.1 (3.62)	21	56.1	1178.2
Deltamethrin	0.005	98.6 (9.99)	81.6 (9.36)	65.8 (8.14)	32.1 (5.60)	21	69.4	1458.3
	0.0025	93.8 (9.72)	57.1 (7.60)	45.2 (6.79)	19.2 (4.42)	21	53.6	1126.4
	0.00125	82.9 (9.09)	48.7 (7.00)	30.0 (5.51)	3.4 (1.82)	21	41.0	861.1
Endosulfan	0.07	100.0 (10.05)	68.3 (8.31)	17.0 (5.58)	4.1 (2.01)	21	47.2	991.6
	0.035	90.4 (9.51)	62.2 (7.90)	15.4 (3.52)	0.4 (1.12)	21	41.9	880.3
	0.0175	74.2 (8.65)	19.1 (4.25)	4.1 (2.11)	0.0 (1.00)	15	24.0	359.6
Malathion	0.1	87.5 (9.37)	46.2 (6.78)	30.4 (5.56)	2.1 (1.51)	21	41.3	867.4
	0.05	70.0 (8.26)	42.1 (6.52)	13.3 (3.66)	0.0 (1.00)	15	31.1	465.8
	0.025	50.4 (7.15)	7.9 (2.82)	1.3 (1.31)	0.0 (1.00)	15	14.4	216.4
Untreated check	Water	0.8 (1.19)	1.6 (1.38)	0.0 (1.00)	0.0 (1.00)			
CD ($P=0.05$)		(0.64)	(1.23)	(1.45)	(1.34)			

on stinging nettle from USA.

The caterpillars started feeding on hop plantations by the end of May during 1996 and 1997 but was delayed to second week of June during 1995. The infestation index worked out revealed the peak values of 31.6, 14.2 and 22.4 in the three consecutive years which occurred 4-5 weeks after the initiation of infestation in the end of June to early July with the corresponding larval population of 90.4, 59.3 and 80.1 larvae/vine and the infestation level of 35, 24 and 28%. Neither any conclusive relationship with the environmental factors except rainfall ($r = -0.3942$; significant at $P=0.01$) could be established owing to wide variation in day to day environmental parameters nor the mechanism of over-wintering could be ascertained.

Natural enemies

The caterpillars of *V. cashmirensis* were found to be parasitized by an ichneumonid (indetermined) larval-pupal parasitoid resulting in mortality up to 18.3% (mean: 9.4, 11.5 and 9.6% during three consecutive years). Spiders were also observed feeding on the egg masses and the small caterpillars (I-III instar), however the later stages were predated upon by the *Vespa* spp though the extent of predation being negligible.

Evaluation of insecticides

Observations pertaining to field weathered toxicity of

insecticides to third instar caterpillars revealed that all the insecticides were superior to untreated check in causing mortality at 1 day after treatment (Table 2). Carbaryl, chlorpyrifos, cypermethrin and deltamethrin (except 0.00125%) were more toxic to remaining insecticidal treatments. At 8 day after treatment, toxicity of all the insecticides at low concentrations declined except in malathion where higher and median concentrations too had a sharp declining trend. A further reduction in toxicity was observed in all the treatments at 15 day after treatment but carbaryl (0.2%), cypermethrin (0.015 and 0.0075%), chlorpyrifos (0.08%) and deltamethrin (0.005%) recorded > 50% larval mortality. However at 21 day after treatment, mortality in all the insecticidal treatments declined except cypermethrin (0.015%) and carbaryl (0.02%).

On the basis of persistent toxicity values (Table 2) it can be concluded that carbaryl, chlorpyrifos and cypermethrin at all the concentrations were more toxic to the caterpillars and can protect the hop plantations for longer duration in comparison to other insecticides. Thus, destruction of the alternate host-stinging nettle, *Urtica dioica* nearby hop plantations; collection and destruction of egg clusters/ young caterpillars at 10 day interval; and foliar application of cypermethrin (0.0075%)/ carbaryl (0.1%)/ chlorpyrifos (0.04%) with the appearance of incidence and repeating after 15 days, if the attack persists.

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Performance of exotic cultivars of gerbera (*Gerbera jamesonii*) under low cost naturally ventilated greenhouse environment

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ABSTRACT

The performance of 9 exotic cultivars of gerbera, viz Diablo, Lyonella, Ornella, Sunset, Tara, Thalassa, Tiramisu, Twiggy and Whitsun was studied under lowcost naturally ventilated greenhouse environment. Cultivar Lyonella recorded maximum height of plant (53.49 cm), spread of plant (72.71 cm) and number of suckers (4.55) and leaves (46.66) per plant. Survival percentage of plants up to one year of planting did not differ significantly and varied from 86.11 % in case of cultivar Whitsun and 100 % in case of cultivars Ornella and Twiggy. The earliest (38.22 and 51.13 days) and latest (86.66 and 94.74 days) flowering were observed in cultivars Whitsun and Tiramisu, respectively. The maximum flower diameter (10.44 cm), stalk length (64.00 cm), stalk thickness (0.75 cm diameter) and fresh weight of stalk (23.01 g) were recorded in cultivars Thalassa, Lyonella, Tiramisu and Ornella, respectively. Higher yield (number) of flowers per plot and per plant per year was obtained in Diablo (1 223.33 and 54.67) followed by Lyonella (1 092.33 and 47.76), Ornella (1 073.66 and 46.28) and Thalassa (1 067.00 and 46.26) and the minimum in cultivar Tara (501.66 and 21.60). The highest 1st grade (96.42%) and lowest IInd grade (3.32%) and IIIrd grade/unmarketable (0.25%) flowers were recorded in cultivar Twiggy, followed by Sunset (94.36%, 5.13% and 0.49% respectively), Tiramisu (92.70%, 6.83% and 0.45% respectively) and Lyonella (92.69%, 6.48% and 0.64% respectively). The lowest 1st grade flowers (79.81%) and the highest unmarketable flowers (12.51%) were obtained in cultivar Whitsun. The temperature inside the greenhouse varied from 28°C to 36.9°C and the temperature build-up could be controlled from 1.1°C to 3°C. The relative humidity inside the greenhouse varied from 24 to 70% when outside relative humidity varied from 20 to 70%.

Key words: *Gerbera jamesonii*, gerbera, exotic cultivar, low cost natural ventilation greenhouse, growth, number of flowers, grading of flowers, environmental parameters, temperature, relative humidity

Gerbera (*Gerbera jamesonii* Bolus ex Hook. f.), is an important cut flower crop being grown throughout the world in a wide range of climatic condition. Its flowers come in wide range of colours including yellow, white, red, orange, pink, maroon, crimson and various other intermediate shades. The flowers are also available in different forms like single, semi-double, double, quilled and a few related types. There is a very good demand of gerbera from European markets particularly during winter and almost throughout the year in India. India has wide opportunities to cultivate gerbera on a commercial scale. However, it is difficult to get exportable or even for domestic market good quality cut blooms of gerbera under open field condition (Khan 1999). Hence, to meet the qualitative and quantitative standards, the high yielding and long lasting exotic cultivars have to be

grown under some sort of protected environments. In recent years, due to liberalization of import policies, several enthusiastic entrepreneurs and nurserymen are getting latest and imported gerbera cultivars from abroad for cultivation on commercial scale. Locally, several companies have also started supplying imported plant materials multiplied through tissue culture technique. Performance of gerbera cultivars varies with the region, season and growing environments. Birdar and Khan (1996) have evaluated 3 growing environments, viz under lowcost polyhouse, under 50 % shade net and under open field condition for 5 exotic cultivars of gerbera under Bangalore condition and recommended cultivation of exotic gerbera under low cost polyhouse condition. In India, particularly where mild climate is gifted by nature (Bangalore, Pune, etc) larger acreage of gerbera cultivation is under low cost naturally ventilated polyhouse condition (authors' personal experience). Therefore, the present study was planned to evaluate 9 exotic cultivars of gerbera for their productivity, quality and adaptability under naturally ventilated insect proof low cost greenhouse condition.

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Table 1 Temperature and relative humidity recorded in naturally ventilated system polyhouse and ambient condition

Month	Temperature (°C)			Relative humidity (%)		
	Inside polyhouse	Ambient	Difference in polyhouse (±)	Inside polyhouse	Ambient	Difference in polyhouse (±)
July (A) 98	32.2	31.2	+1.1	52	47	+5.0
July (B) 98	29.2	28.0	+1.2	61	64	-3.0
August (A)	29.5	28.0	+1.5	70	70	0.0
August (B)	31.2	28.2	+3.0	63	64	-1.0
September (A)	30.2	28.4	+1.8	62	62	0.0
September (B)	30.4	28.8	+1.6	59	61	-2.0
October (A)	29.8	28.5	+1.3	65	64	+1.0
October (B)	29.7	28.5	+1.2	58	58	0.0
November (A)	28.0	26.8	+1.2	70	68	+2.0
November (B)	29.9	28.5	+1.4	53	49	+4.0
December (A)	28.0	26.7	+1.3	53	56	+1.0
December (B)	29.0	27.8	+2.2	57	42	+4.0
January (A)	29.5	28.0	+1.5	46	45	0.0
January (B)	30.6	28.4	+2.2	45	29	+5.0
February (A)	31.9	30.5	+1.4	34	37	+3.0
February (B)	34.5	33.0	+1.5	40	22	+2.0
March (A)	35.5	34.0	+1.5	24	20	+4.0
March (B)	36.9	35.4	+1.5	24	26	+4.0
April (A)	36.6	34.9	+1.7	30	25	+6.0
April (B)	35.7	33.7	+2.0	31	38	-4.0
May (A)	34.6	32.8	+1.8	34	51	-1.0
May (B)	33.5	31.0	+2.5	50	54	-1.0
June (A)	31.7	30.4	+1.3	53	52	+4.0
June (B)	32.1	29.8	+1.1	57	53	-1.0
Average	31.67	29.95	+1.72	49.58	48.20	+1.38

A, First fortnight; B, second fortnight

MATERIALS AND METHODS

Greenhouse structure

A low cost (east-west oriented) naturally ventilated, insect-proof greenhouse of 360 m² area was fabricated on contract basis at the Indian Institute of Horticultural Research, Hessarahatta, Bangalore, during 1997. The construction cost of this greenhouse during 1997 was Rs 250000 (approximately). The dimension of the structure was 30 m length, 12 m width, 3 m side height and 5 m peak roof height. In 12 m width, 2 spans of 6 m width were provided having a 32 m long 24 gauge GI sheet gutter. The greenhouse structure was clad with single layer of 200 micron (800 gauge) thick ultra-violet stabilized low density polythene film (200 μ LDPE). For natural cross ventilation and protection of crop from outside entering pests. Both sides (lengthwise) of this polyhouse were covered with white insect proof high density polythene (HDPE) fabrics (40 × 40 mesh) leaving 1 m LDPE covered space from ground level. In both spans 1 m wide 40 mesh net was also provided on the roof along the length of greenhouse to provide ventilation by thermal buoyancy. The total naturally ventilated area was 120 m² which is 33.3 % of total floor area. In both sides of ventilated area, besides 40 mesh, a rollable flap of 200 micron thick LDPE was also

provided outside the polyhouse to regulate temperature and humidity depending upon the season and also to protect crop from rains. 50 % agro shade net of green colour was fitted at 3 m height inside the roof of polyhouse, which was spread and rolled upside according to requirement, to provide shade as well as cooling effect to the crop as and when required. Drip irrigation system was installed on the entire cropped area of polyhouse. Dry and wet bulbs temperatures were recorded at 1 pm daily in the centre of polyhouse and ambient conditions from July 1998 to June 1999. The mean of dry and wet bulbs temperatures and relative humidity at fortnight intervals are presented in Table 1. Mean maximum and minimum temperature was 27.1–33.9°C and 14.1–20.8°C respectively, relative humidity was 46.1–82.7% and 25.0–68.5% at 7.30 hr and respectively and monthly rainfall ranged from 10.5–393.6 mean during the year at experimental station.

Planting material and package of cultural practices

Beds of 14 m length, 1 m width and having 30 cm height were prepared by mixing of well rotten farmyard manure (nutritional status is given in Table 2) and fine sand @ 7.5 kg/sq.m and 3 kg/m² respectively. The prepared beds were fumigated with 4 % concentrated solution of formaldehyde

(Formalin) HCHO=30.03, @ 1.8 l/m² area basis and covered with polythene film for seven days. Ten days before planting, neem cake @ 500 g/m² and nitrogen, phosphorus and potassium @ 10:15:20 g/m² were supplied to sterilized beds. Nine exotic cultivars of gerbera (treatments) were selected for this experiment (Table 3). Two months old tissue cultured plants having uniform vegetative growth were procured and transplanted on 1 July 1998, at a spacing of 30 cm (row) × 30 cm (plant) accomodating 3 rows per bed widthwise. For each treatment (cultivar) 8 rows per plot (2.40 m length) were planted, having 24 plants per treatment (cultivar). The treatments were replicated thrice in randomised block design. The polyhouse had 62.2 % total cropped area. Up to 2 months of transplanting, watering was done through water can by hand; thereafter drip irrigation was provided. Application of 10:15:20 g NPK/m²/month during first 3 months and 15:10:30 g NPK/m²/month from 4th month onwards was supplied through urea, single super phosphate and sulphate of potash

Table 2 Soil status of naturally ventilated polyhouse

Parameter	Sample value	Standards
PH	6.59	6.00 – 8.00
Electrical conductivity (dS/m)	0.13	0.00 – 1.00
Organic carbon (%)	0.78	More than 1.00
Available nitrogen (ppm)	126.30	100 – 200
Available phosphorus (ppm)	7.69	50 – 100
Available potash (ppm)	207.50	500 – 800
Available calcium (ppm)	1 575.00	500 – 2 000
Available magnesium (ppm)	268.00	350 – 500
Available sulphur (ppm)	5.00	10 – 50
Available ferrous (ppm)	12.36	2 – 10
Available molybdenum (ppm)	26.00	2 – 20
Available zinc (ppm)	1.42	1 – 5
Available copper (ppm)	88.00	0.20 – 2.00

respectively. Multiplex (a micronutrients mixture) @ 2 ml/l was also supplied through foliar spray at bimonthly intervals. Uniform package of cultural practices as suggested by Khan (1999) were followed during entire course of experimentation. The flowers were harvested when outer 2 - 3 rows of disc florets were fully developed. Experiment was continued upto one year of transplanting (June 1999). Observations on vegetative growth parameters such as mean height and spread of plant and number of suckers and leaves per plant and survival percentage of plant (Table 4) were recorded just a year after transplanting. The qualitative parameters of flowers such as mean fresh weight of flower stalk and diameter, length and thickness of cut flowers were recorded 5 months after transplanting when all plants were fully grown up and started profuse flowering (Table 5). Number of days taken for flowering and yield of flowers were recorded from flowering stage up to June 1999. Cut flowers were graded according to Polish Gerbera Classification (Birdar and Khan 1996) - Stalk length and flower diameter above 50 cm and 10 cm

Table 3 Details of gerbera cultivars planted

Name of cultivar	Colour of flower	Type
Diablo	Red (45.A)	Semi double + Black centre
Lyonella	Yellow (7.A)	Single
Ornella	Orange-Red(33.A)	Semi double
Sunset	Orange-Red (30.B)	Semi double + Black centre
Tara	Orange (28.A)	Double
Thalassa	Yellow (9.A)	Semi double + Black centre
Tiramisu	Yellow-Orange (19.B)	Semi double + Black centre
Twiggy	Red-Purple (67.A)	Double
Whitsun	Pure White	Single

respectively are classified as Ist (A) grade, between 30-50 cm and 8-10 cm were grouped in II nd (B) grade and stalk length below 30 cm, attacked by pests and malformed were classified under IIIrd (C) grade and therefore treated as unmarketable or discard (Table 5). The colour of flower heads were compared with the Horticultural Colour Chart issued by British Colour Council in collaboration with the Royal Horticultural Society in natural light (Anonymous 1938) and presented in (Table 3).

RESULTS AND DISCUSSION

Vegetative growth

It is evident from the analysed data presented in Table 4 that vegetative growth parameters varied considerably in respect of different cultivars. The cultivar Lyonella recorded maximum height of plant (53.49 cm), number of suckers (4.55) and leaves (46.66) per clump and spread of plant (72.71 cm). The cultivar Tara recorded minimum number of suckers (3.49) and leaves (28.10) per clump. The minimum height of plant (38.68 cm) and spread of plant (62.16 cm) was obtained with cultivar Whitsun. The marked variation in vegetative growth parameters may be due to varietal characters that expressed their genetical character. Variation in vegetative growth parameters in 5 cultivars of gerbera and 10 cultivars of carnation grown under greenhouse condition have been reported by Birdar and Khan (1996) and Bhautkar (1994), respectively. Table 4 also indicates that establishment of plants did not differ significantly in different cultivars tried. Although, the 100% survival was recorded in cultivars Ornella and Twiggy and the minimum of 86.11% in Whitsun. Non-significant difference in plant establishment of different cultivars might be due to the fact that all plants were multiplied under same aseptic tissue culture laboratory and thereafter uniform environments for their hardening and crop production were provided. After transplanting under greenhouse also

Table 4 Mean vegetative growth parameters in exotic gerbera cultivars recorded under naturally ventilated greenhouse environment

Name of Cultivar	Height of plant (cm)	Number of suckers/plant	Number of leaves/plant	Spread of plant (cm)	Plant establishment (%)
Diablo	38.99	4.10	38.72	63.88	97.22
Lyonella	53.49	4.55	46.66	72.71	97.22
Ornella	43.27	4.49	45.94	67.10	100.00
Sunset	43.71	3.71	33.49	67.88	83.33
Tara	42.10	3.49	28.10	65.94	95.81
Thalassa	46.82	4.38	33.94	72.94	97.22
Tiramisu	45.38	4.10	38.49	68.27	94.44
Twiggy	44.10	3.72	30.05	67.83	100.00
Whitsun	38.68	4.10	41.05	62.16	86.11
SEm±	1.13	0.18	3.02	1.71	NS
CD(P=0.05)	3.41	0.56	9.06	5.14	
CD(P=0.01)	4.70	0.78	12.48	7.08	

uniform plant protection measures were followed during entire experimentation.

Floral characters

Gerbera cultivars under study took 38.22 to 86.66 days for 50 % flowering and 51.13 to 94.74 days for 100 % flowering from the date of transplanting in the naturally ventilated greenhouse condition. The earliest flowering was recorded in Whitsun (38.22 and 51.13 days) followed by Diablo (58.30 and 65.44 days). The latest flowering was observed in Tiramisu (86.66 and 94.74 days) followed by Twiggy (74.72 and 80.81 days) and Lyonella (74.38 and 80.51 days). Accordingly cultivars may be used for having a prolonged blooming period merely by way of selection (Table 5). Early and late flowering were found to be genetically controlled.

The flower quality parameters such as mean length, thickness and fresh weight of flower stalk and diameter of flower were significantly different from one cultivar to another (Table 5). Better performance of the above parameters are quite vital so far as commercial value of cut gerbera flowers is concerned. The maximum flower diameter (cm) is recorded in Thalassa (10.44), Tara (10.34) and Tiramisu (10.25) and the minimum in Whitsun (8.66) followed by Diablo (9.05). The maximum length of flower stalk (cm) was recorded in Lyonella (64.00) followed by Tara (53.08). The thickest flower stalk (cm) was recorded in Tiramisu (0.75) followed by Twiggy (0.71) and Thalassa (0.70) and the thinnest flower stalk was obtained in Whitsun (0.57). The heaviest flower stalk (g) was recorded in Ornella (23.01) followed by Twiggy (22.96) and Thalassa (22.52) and the lightest in Whitsun (15.14) followed by Diablo (19.03). These differences in cut flower quality parameters might be due to inherent characters of the individual cultivars. These findings are also in accordance with the results of Gotz (1983) and Birdar and Khan (1996) who reported large differences in quality parameters of different gerbera cultivars.

Total yield of flowers per plot per year, per plant per year and mean number of flowers per plant per month in a year and % of different grades of flowers (I, II, III) produced per plot in a year have been significantly affected due to different cultivars (Table 5). The maximum number of flowers per plot (1 223.33), per plant (54.67) and per month (5.69) in a year was produced by Diablo, followed by Lyonella (1 092.33, 47.76 and 5.29), Ornella (1073.66, 46.28 and 4.97) and Thalassa (1 067.00, 46.26 and 4.73) and the minimum by Tara (501.66, 21.60 and 2.33). The maximum first grade (96.42%) and minimum second grade (3.32%) and discarded (0.25%) flowers were recorded in Twiggy, followed by Sunset (94.3 %, 5.13% and 0.49%, respectively), Tiramisu (92.70%, 6.83% and 0.49%, respectively) and Lyonella (92.69%, 6.48% and 0.64%, respectively). The minimum first grade flowers (79.81%) and maximum discarded (12.51 %) flowers were produced by Whitsun. These differences are due to inherent characters of individual cultivar. Biradar and Khan (1996) and Bhautkar (1994) have also reported variations in total yield of flowers and the corresponding grading in gerbera and carnation respectively grown under greenhouse condition.

Environmental parameters

The temperature inside greenhouse varied from 28°C in November and December to 36.9°C during March (Table 1). The build up of the temperature inside greenhouse was 1.1°C to 3.0°C with an average of 1.72°C and the excessive build up of the temperature could be avoided due to proper ventilation. The relative humidity in the greenhouse varied from 29% in February and March to 70% during August and November with average build up of relative humidity by 1.38%. The relative humidity inside greenhouse could be controlled within limits of +5 % to -3 % from ambient relative humidity due to proper ventilation.

It can be concluded that cultivars Diablo, Lyonella, Ornella, Thalassa, Tiramisu and Twiggy were good not only

Table 5 Floral parameters in exotic gerbera cultivars recorded under naturally ventilated greenhouse environment (upto a year after transplanting)

Cultivar	Mean no. of days taken for flowering		Flower diameter (cm)	Stalk length (cm)	Flower stalk thickness (cm)	Fresh weight of flower stalk (g)	Total number of flowers produced			Grading of flowers (%)		
	(50%)	(100%)					plot/year	plant/year	plant/month	First (A)	Second (B)	Discard (C)
Diablo	58.30	65.44	9.05	51.04	0.65	19.03	1 223.33	54.67	5.69	85.31	14.32	0.36
Lyonella	74.38	80.51	9.10	64.00	0.69	19.86	1 092.33	47.76	5.25	92.69	6.48	0.64
Ornella	66.47	72.96	9.25	57.74	0.64	23.01	1 073.66	46.18	4.97	80.40	17.47	2.11
Sunset	69.79	74.05	10.35	63.53	0.68	20.04	747.33	35.85	3.87	94.36	5.13	0.49
Tara	70.41	78.60	10.34	53.08	0.66	20.97	501.66	21.60	2.23	82.25	17.43	0.38
Thalassa	60.27	65.77	10.44	57.94	0.70	22.52	1 067.00	46.26	4.73	89.58	9.40	0.98
Tiramisu	86.66	94.74	10.26	54.59	0.75	18.18	739.00	32.67	3.54	92.70	6.83	0.45
Twiggy	74.42	80.81	9.87	57.71	0.71	22.96	872.00	38.41	3.95	96.42	3.32	0.25
Whitsun	38.22	51.13	8.66	58.30	0.57	15.14	754.33	37.41	3.88	79.81	7.68	12.51
SEm+	3.32	3.45	0.32	2.04	0.02	1.13	54.98	2.25	0.47	1.94	1.56	0.23
CD ($P=0.05$)	9.96	10.35	0.96	6.14	0.06	3.39	164.83	6.75	1.43	5.83	4.66	0.69
CD ($P=0.01$)	13.72	14.27	1.32	8.46	0.09	4.68	227.10	9.30	1.98	8.03	6.42	0.96

in yield but also in quality as compared to others and may be recommended for commercial cultivation under low cost naturally ventilated greenhouse condition in and around Bangalore or places having similar mild climates.

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Evaluation of insecticidal schedules for the management of bud fly (*Dasyneura lini*) in linseed (*Linum usitatissimum*)

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ABSTRACT

Field experiments conducted during 1995-97 on the bioefficacy of different insecticidal schedules for the management of bud fly (*Dasyneura lini* Barnes) in linseed (*Linum usitatissimum* L.) revealed that two foliar sprays of phosphamidon (0.03%) along with soil drenching of chlorpyrifos (0.05%) had significantly minimum bud fly infestation of 15.71% with higher seed production of 2 055.55 kg/ha, providing Rs 15 578/ha as net monetary return. However, alternate application of phosphamidon (0.03%) followed by deltamethrin (0.002%) also had significantly lower bud infestation (17.45%) with 1 972.22 kg/ha seed yield having maximum net monetary return of Rs 15 633/ha with higher benefit : cost ratio of 22.33: 1. Average avoidable losses in yield were estimated up to 60.81%.

Key words: linseed, bud fly, insecticides, bio-efficacy, economics

Among the biotic constraints responsible for the low productivity in linseed, insect-pests are of prime significance. Bud fly, *Dasyneura lini* Barnes is the key pest causing up to 88% yield losses (Pal *et al.* 1978, Malik *et al.* 1998). However, two fortnightly applications either of phosphamidon (0.03%), endosulfan (0.07%), deltamethrin (0.002%) or chlorpyrifos (0.05%) have been reported effective against bud fly infestation (Jakhmola 1973, Singh *et al.* 1991, Malik *et al.* 1996), but continuously repeated applications of a single insecticide may pose adverse effects including resistance in insect-pests. The present investigations were taken up to test the efficacy of combinations of different insecticides to sustain the productivity of linseed by reducing pest caused losses and work out the beneficial one.

MATERIALS AND METHODS

Field trials were conducted on 'Neelum' linseed for the bio-efficacy of different combinations of insecticides against bud fly (*Dasyneura lini* Barnes) at the research farm of the university during rabi 1995-96 and 1996-97. The crop was sown during the end of November in randomized block design replicated thrice in 3 m × 3 m plot size during each year and all recommended agronomical practices were followed. Fourteen combination of different insecticides, viz T₁ - chlorpyrifos 20 EC (0.05%) as soil drenching, T₂ - chlorpyrifos 20 EC (0.03%) as soil drenching, T₃ - methyl parathion 2% dust @ 25 kg/ha as soil application, T₄ - methyl parathion 2%

dust @ 15 kg/ha as soil application, T₅ - malathion 50 EC (0.05%), T₆ - monocrotophos 36 SL (0.04%), T₇ - endosulfan 35 EC (0.07%), T₈ - phosphamidon 85 SL (0.03%), T₉ - T₁ + T₈, T₁₀ - T₂ + T₈, T₁₁ - T₃ + T₈, T₁₂ - T₄ + T₈, T₁₃ - alternate application of phosphamidon and deltamethrin 2.8 EC (0.002%) and T₁₄ - untreated control were applied at fortnightly intervals starting from bud initiation stage of the crop. Bud fly infestation was recorded on three randomly selected plants replication-wise before and after each spray and finally at dough stage. Grain yield was recorded after harvest of the crop. The data for both the years were computed on pooled basis for critical differences and the economic analysis.

RESULTS AND DISCUSSION

Bud fly infestation

Bud fly infestation varied numerically from 3.68 to 5.24% before insecticidal application, but it ranged significantly from 11.05 to 38.57% after 14 days of first spray (Table 1). At this stage, significantly minimum (11.05%) bud infestation was recorded on the crop sprayed with phosphamidon 0.03% along with soil drenching of chlorpyrifos 0.05%, against maximum (38.57%) in untreated plots. This particular treatment maintained its superiority over other treatments and had significantly minimum 15.71% bud infestation at dough stage of the crop, which was at par with 17.45, 18.11, 18.53, 19.05 and 19.87% bud infestation recorded on the crop treated with alternately applied phosphamidon and deltamethrin, phosphamidon+chlorpyrifos (0.05% soil

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Table 1 Effect of different insecticidal schedules on bud fly infestation and seed yield in linseed

Treatment	Bud fly infestation (%)				Seed yield (kg/ha)
	Before spray	First spray	Second spray	Dough stage	
T ₁	4.14 (11.78)	22.11 (28.05)	32.55 (34.79)	38.53 (38.37)	1 222.22
T ₂	3.85 (11.32)	27.35 (31.53)	35.63 (36.65)	42.45 (40.66)	1 089.38
T ₃	5.07 (13.01)	27.00 (31.30)	39.95 (39.20)	41.64 (40.19)	1 138.88
T ₄	4.65 (12.46)	20.60 (27.00)	33.08 (35.11)	43.63 (41.34)	1 064.81
T ₅	5.15 (13.12)	16.10 (23.66)	25.58 (30.38)	26.12 (30.74)	1 416.67
T ₆	4.44 (12.16)	17.18 (24.48)	21.74 (27.79)	24.97 (29.86)	1 583.33
T ₇	5.24 (13.23)	13.63 (21.66)	17.38 (24.64)	21.56 (27.67)	1 712.35
T ₈	3.68 (11.07)	12.09 (20.35)	17.52 (24.74)	19.87 (26.47)	1 777.78
T ₉	3.84 (11.30)	11.05 (17.41)	14.57 (22.44)	15.71 (23.35)	2 055.55
T ₁₀	4.77 (12.62)	15.25 (22.99)	16.08 (23.64)	18.11 (25.19)	1 916.67
T ₁₁	4.18 (11.80)	13.79 (21.80)	17.65 (24.84)	18.53 (25.50)	1 833.33
T ₁₂	4.24 (11.89)	13.59 (21.63)	17.64 (24.83)	19.05 (25.88)	1 805.55
T ₁₃	4.62 (12.41)	11.30 (19.64)	15.62 (23.28)	17.45 (24.69)	1 972.22
T ₁₄	4.54 (12.31)	38.57 (38.39)	50.40 (45.23)	53.68 (47.11)	8 05.55
SE (m) ±	0.68	1.81	1.24	1.42	1 22.03
CD (P = 0.05)	NS	5.25	3.61	4.13	354.81

Figures in parentheses are angular transformed values

Table 2 Economic analysis of different insecticidal schedules in linseed

Treatment	Cost of treatment (Rs/ha)	Yield (kg/ha)	Cost of increased yield over control (Rs/ha)	Net monetary return (Rs/ha)	Benefit : cost ratio
T ₁	1 482	1 222.22	5 833	4 351	2.93
T ₂	1 002	1 089.38	3 974	2 972	2.96
T ₃	423	1 138.88	4 667	4 244	10.03
T ₄	235	1 064.81	3 630	3 395	14.45
T ₅	554	1 416.67	8 556	8 002	14.44
T ₆	840	1 583.33	10 889	10 049	11.96
T ₇	1 114	1 712.35	12 695	11 581	10.40
T ₈	534	1 777.78	13 611	13 077	24.49
T ₉	1 922	2 055.55	17 500	15 578	8.11
T ₁₀	1 442	1 916.67	15 556	14 114	9.79
T ₁₁	957	1 833.33	14 389	13 432	14.03
T ₁₂	889	1 805.55	14 000	13 111	14.75
T ₁₃	700	1 972.22	16 333	15 633	22.33
T ₁₄		805.55			

drenching), phosphamidon + methyl parathion 2% dust @ 25 kg/ha (soil mixing), phosphamidon + methyl parathion 2% dust @ 15 kg/ha (soil mixing) and phosphamidon, respectively. Reduction in bud fly infestation was 18.72 - 70.73% due to different insecticidal schedules against significantly maximum bud fly infestation (53.68%) in untreated crop. Significantly higher seed production of linseed recorded 2 055.55 kg/ha was in phosphamidon with soil drenching of chlorpyrifos (0.05%) applied crop, which was at par with the yields obtained from the treatments of alternate sprays with phosphamidon deltamethrin (1 972.22 kg/ha), phosphamidon with chlorpyrifos (0.03%) as soil

drenching (1 916.67 kg/ha), phosphamidon with methyl parathion @ 25 kg/ha soil application (1 833.33 kg/ha), phosphamidon with methyl parathion @ 15 kg/ha soil application (1 805.55 kg/ha), phosphamidon (1 777.78 kg/ha) and endosulfan (1 712.35 kg/ha), against the lowest production of 805.55 kg/ha in untreated crop. The extent of yield losses were recorded as high as 60.81%. Earlier reports of Singh *et al.* (1984, 1991, 1995) and Malik *et al.* (1996) advocated two applications either of phosphamidon or deltamethrin or chlorpyrifos, but their views are superceded in these findings by evaluating the better efficacy of more than one insecticidal combination in comparison to their

sole applications, which may be helpful in reducing the problem of insect resistance to insecticides owing to repeated application of the same insecticide.

Economics

Application of different insecticidal treatments resulted in the reduction of bud fly infestation and enhancement in seed production. Maximum increase in yield over untreated crop was 1 250 kg/ha costing Rs 1 7500/ha with net monetary return Rs 15578/ha in phosphamidon as foliar spray along with soil drenching of chlorpyrifos (0.05%) treated crop, but the higher net monetary return of Rs 1 5633/ha was gained from the crop treated alternately with phosphamidon and deltamethrin. The benefit : cost ratio was maximum 24.49 : 1 in phosphamidon treated crop followed by 22.33 : 1 in alternate application of phosphamidon and deltamethrin treatment (Table 2). These results are in conformity with those of Singh *et al.* (1991, 1995) and Malik *et al.* (1996, 1997), who reported better net monetary return with higher BCR from phosphamidon treated crop.

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Nitrogen requirement of single hybrid maize (*Zea mays*) - wheat (*Triticum aestivum*) system under rainfed conditions

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ABSTRACT

A field experiment was conducted during *kharif* 1997 at Bajaura to work out nitrogen requirement of single hybrid maize (*Zea mays* L.) grown under rainfed conditions. The grain and stover yield of maize increased significantly up to 120 kg /ha of N applied. Farmyard manure at 15 tonnes/ha improved maize productivity to a considerable extent. However, wheat (*Triticum aestivum* L. emend. Fiori & Paol.) grain and straw yield increased significantly up to 90 kg/ha of N applied. The response of wheat crop to farmyard manure was similar as obtained in maize. The total uptake of N by maize and wheat crops increased with increasing level of nitrogen and farmyard manure but it had no effect on P and K uptake. The addition of farmyard manure @ 20 tonnes/ha improved total uptake of all the nutrients. The status of available N in soil improved due to nitrogen fertilization but P and K did not. The availability of these nutrients further increased with farmyard manure application. Application of 120 kg N/ha + 15 tonnes farmyard manure/ha was found best treatment for hybrid maize grown under rainfed conditions.

Key words : nitrogen requirement, maize, *Zea mays*, hybrid, rainfed, Himachal Pradesh

Maize (*Zea mays* L.) crop in Himachal Pradesh under rainfed conditions occupies a significant proportion of cultivated area. Growing local and composite maize varities had been a common practice by farmers since long and a good deal of information exists on their nutrient requirements. With the introduction of hybrids in the state, their use has also come up on larger scale. However, the information on nutrient requirements of single hybrid of maize cultivars was lacking. The present study was, therefore, undertaken as the majority of the soils supporting maize cultivation have poor N status but medium in soil P and well supplied with available K.

MATERIALS AND METHODS

A field experiment of three years duration was started with maize hybrid 'EHB 1520' in rainy season (*kharif*) 1997 followed by wheat in the winter season (*rabi*), 1997-98 at Regional Research Station, Bajaura, Kullu (1 090 m above mean sea level). Three cycles of the system were completed in the fixed plots. The soil of experimental area was sandy loam in texture, acidic in reaction (pH 6.2), low in available nitrogen (212 kg/ha), medium in available P (17.4 kg/ha) and high in available K (140 kg/ha) at the beginning of the experiment. The experiment was laid out in randomized block design with four levels of nitrogen (30, 60, 90 and 120 kg/ha) and three of farmyard manure (10, 15 and 20 tonnes/ha)

applied to maize crop. The residual effect of nitrogen and farmyard manure was studied in wheat crop. The crop was uniformly fertilized with recommended dose of N (60 kg/ha), P (40 kg/ha) and K (30 kg/ha). The whole quantity of P, K was applied to maize crop through single superphosphate and muriate of potash respectively along with farmyard manure as per the treatments. One third quantity of nitrogen was applied at the time of sowing through urea and remaining in two equal splits at knee high and pretasseling stages of the crop. Wheat crop received one third quantity of N at sowing and remaining in two equal splits at maximum tillering and flowering stages. The maize hybrid was sown at 60 cm × 20 cm spacing in second week of June every year. 'HPW 42' variety of wheat was sown at a row spacing of 20 cm during last week of November every year. The grain and stover/straw samples of maize and wheat were collected at harvest stage and the concentration of N, P and K was determined using standard procedures. The uptake of nutrients was calculated by multiplying yield (kg/ha) with nutrient concentration (%). The soil samples collected after harvest of the final crop (wheat 1999-2000) were analysed for available N (Subbiah and Asija 1956), P (Olsen *et al.* 1954) and K (Merwin and Peech 1951).

RESULTS AND DISCUSSION

Grain and stover/straw yield

The grain and stover yield of maize increased consistently and significantly with increasing levels of N (Table 1).

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Table 1 Effect of nitrogen and farmyard manure on grain and stover/straw yield of maize and wheat in a sequence (average data of three years)

Treatment	Maize yield (kg/ha)		Wheat yield (kg/ha)	
	Grain	Stover	Grain	Straw
<i>Levels of N (kg/ha)</i>				
30	6 498	7 316	2 761	5 042
60	7 180	7 968	3 050	5 824
90	8 314	8 712	3 512	6 609
120	9 036	9 138	3 649	7 131
CD (P=0.05)	495	310	194	628
<i>Levels of FYM (tonnes/ha)</i>				
10	6 720	8 483	2 573	4 567
15	7 600	9 117	3 368	5 353
20	7 887	9 570	3 644	5 845
CD (P=0.05)	503	442	369	540

However wheat grain and straw yield increased up to 90 kg/ha of nitrogen applied to maize crop and the response beyond this level was not significant. Such a significant increase in grain and straw yield of maize and wheat could be attributed to improved growth, better availability of nutrients at vital growth period and synthesis of carbohydrates and their translocation (Rameshwar and Singh 1987). Application of farmyard manure at 15 tonnes/ha in comparison to 10 tonnes significantly increased grain and straw yield of maize and wheat crops. No significant response was noticed beyond 15 tonnes/ha of farmyard manure. Significant improvement in these parameters following farmyard manure application was a consequence of improved soil conditions and built up of the nutrients due to additional nutrients supplied by farmyard manure. Rameshwar and Singh (1997) also reported similar influence of farmyard manure application on maize productivity.

Nutrient uptake

The total uptake of N in maize and wheat crops increased to a considerable extent with nitrogen application up to 120

kg/ha to maize (Table 2). However, the effect of nitrogen application on uptake of P and K was not significant. Superimposition of farmyard manure further increased nitrogen uptake in both the crops as direct and residual effect. The uptake values obtained with 15 and 20 tonnes/ha of farmyard manure were almost similar but significant differences were observed when compared with 10 t/ha. The positive and significant effect of N and farmyard manure application was due to added supply of nitrogen and proliferous root system resulting in better absorption of water and nutrients besides improved soil physical environment. Grewal and Trehan (1979) and Miller *et al.* 1987 have also reported similar effects of fertilizer and farmyard manure on the uptake of nutrients under different soil-crop-climate conditions.

Nutrients status

The application of nitrogen up to 120 kg/ha significantly increased soil N status over 30 kg/ha of nitrogen (Table 3). However, its application did not improve the availability of soil phosphorus and potash. The contents of soil N, P and K

Table 2 Effect of N and farmyard manure on total N, P and K uptake (kg/ha) in maize-wheat system (average data of three years)

Treatment	Maize			Wheat		
	N	P	K	N	P	K
<i>Levels of N (kg/ha)</i>						
30	85.40	13.39	99.44	95.06	15.49	100.85
60	91.38	17.05	110.98	101.18	21.49	111.30
90	98.74	21.09	118.69	108.38	29.05	119.36
120	105.87	23.62	127.39	116.61	37.20	125.01
CD (P=0.05)	5.01	NS	NS	4.12	NS	NS
<i>Levels of FYM (tonnes/ha)</i>						
10	80.76	14.11	100.55	91.26	14.08	95.24
15	86.62	18.54	113.15	99.03	19.62	102.18
20	89.31	21.84	124.98	106.43	24.64	114.64
CD (P=0.05)	2.10	1.03	8.10	5.24	3.65	6.02

Table 3 Effect of N and farmyard manure on changes in available N, P and K content in soil after the harvest of crop (average data of three years)

Treatment	Available nutrients (kg/ha)		
	N	P	K
<i>Levels of N (kg/ha)</i>			
30	216.4	23.1	169.3
60	222.5	29.8	175.2
90	228.6	36.4	182.2
120	235.1	41.5	191.7
CD (P=0.05)	4.9	NS	5.2
<i>Levels of FYM (tonnes/ha)</i>			
10	226.3	27.2	166.4
15	230.8	33.6	172.3
20	234.9	40.2	176.9
CD (P=0.05)	3.0	4.8	3.1

further increased with 15 tonnes/ha of farmyard manure, but further increase did not show significant effect. The significant build up of soil available nitrogen due to nitrogen application could be attributed to increased activity of N-fixing bacteria. An improved availability of nutrients in farmyard manure treated plots may be a consequence of additional supply of N, P and K through farmyard manure in soil and better soil environment (Sharma *et al.* 1988).

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Dynamics of nitrogen, phosphorus and potassium redistribution in declining 'Thompson Seedless' grape (*Vitis vinifera*) vines*

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Key words: dynamics of nutrients, nitrogen, phosphorus, potassium, grape, *Vitis vinifera*, current season growth

In perennial fruit crops, seasonal growth is the most important factor which influences nutrient absorption and redistribution. Under stress the nutrient requirement of current season growth (CSG) is met by redistribution of nutrients stored in the older perennial vine parts (PVP) and *vice versa* at senescence of the former (Hennerty *et al.* 1980). This phenomenon is more pronounced in deciduous plants which experience alternate periods of growth and dormancy (Tromp and Ovaas 1973). The work reported is an attempt to study this phenomenon in grape (*Vitis vinifera* L.), a tropical fruit crop subjected to regular pruning.

To study the phenomenon under extreme conditions of stress, declining and non-yielding vines were selected and destructively sampled at monthly intervals after forward pruning till the end of the seasonal growth. The plant was separated into leaf, young cane, secondary- and primary-branches and trunk. Representative samples were drawn for determining dry weight and nutrient composition. Analysis of N, P and K was carried out using standard procedures (Jackson 1967). The nutrient contents were calculated assuming an average dry matter for different vine parts (averaged over the entire growing season) to minimize variation between replications (Kato *et al.* 1981). Pooled values for leaf and young cane represent CSG while that of the remaining parts account for PVP. The net gain or loss in biomass, N, P and K was calculated as :

Gain =	Highest nutrient content – during the season	Initial nutrient content
Loss =	Highest nutrient content – during the season	Nutrient content end of the season

It is assumed that gain in one part may be fully or partially accounted for by the loss in the other part and conversely, the loss by gain. It is further assumed that the quantity that cannot be accounted for by redistribution must have come either from root and/or from external sources, i.e., soil since the vines were not fertilized prior to or during

the growing season.

Distribution of biomass between CSG and PVP

One month after pruning, PVP lost biomass significantly and substantially (4 872 g/vine) while CSG gained only 642 g/vine. The biomass of CSG increased significantly again at 2 months and stabilized at that level till the 4th month. A slight decrease was observed at the 5th month. Similarly the biomass of PVP slightly made up the loss and stabilized at that level between the 2nd and 4th months. At the end of the season the biomass increased to 24 802 g/vine which was significantly higher than that at one and 3 months after pruning. These changes suggest that biomass in PVP decreased soon after pruning to meet the requirement of CSG. At the end of the seasonal growth, PVP made a net gain of 2 827 g/vine whereas CSG gained 1 416 g/vine (Table 2). The contribution of CSG to PVP as reverse movement of carbohydrates and sugar at senescence is very small (74 g/vine). Loss in biomass was attributed to the movement of carbohydrates and sugars to developing buds and roots (Meyer and Splittstoesser 1969) or due to the conversion of proteins in these tissues to meet the needs of soluble N of CSG as observed in grape (Schaffer 1981) and apple (O'Kennedy and Titus 1980).

Redistribution of N between CSG and PVP

The total N content in PVP (107.5 g/vine) significantly reduced to 59.07–67.36 g/vine during the first to fourth month while CSG gained 11.3–17.19 g/vine during this period (Table 1). Part of the N mobilized from PVP might have moved to the root also to meet its requirement. At the end of the growth season PVP acted as a sink for N which was partly remobilized from senescing leaves (5.18 g/plant) from CSG and substantially from N absorbed from soil source (Table 2). Groot Obbink *et al.* (1973), Schaffer (1981) and Conradie (1991) also made similar observations in grape. Araujo and Williams (1988) indicated that roots played a minor role in the dynamics of N in vines.

Redistribution of P between CSG and PVP

Total P content in the perennial vine parts was 14.5 g/

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Table 1 Biomass and nutrients (g/vine) in current season growth (CSG) and perennial vine parts (PVP) in 'Thompson Seedless' grape following forward pruning

Sampling time	Biomass		Nitrogen		Phosphorus		Potassium	
	CSG	PVP	CSG	PVP	CSG	PVP	CSG	PVP
At pruning		21 975		107.53		14.448		74.32
One month	642	17 103	11.29	65.28	2.289	16.156	7.94	85.50
Two months	1 358	21 168	17.19	62.13	3.345	15.717	15.67	73.70
Three months	1 353	19 403	12.09	59.07	2.527	13.708	9.32	69.01
Four months	1 416	21 525	13.43	67.36	3.086	18.206	10.59	35.57
Five months	1 342	24 802	12.01	102.36	1.869	13.801	7.09	118.08
SEm	83	1 370	1.25	3.16	0.189	0.595	1.60	8.03
CD (P=0.05)	244	3 990	3.69	9.20	0.558	1.730	4.72	23.38

vine at pruning which increased in the first month and decreased gradually to 13.8 g/vine when seasonal growth had ceased (Table 1). In the meantime, P content in the seasonal growth increased to 3.3 g/vine which at the end of seasonal growth decreased abruptly to 1.87 g/vine. Perennial vine parts made a net gain of 3.76 g/vine and a net loss of 4.41 g/vine (Table 2). This dynamics of P within the vine indicates that PVP is potentially capable of meeting the P requirement of CSG. In grape the movement of P is considerable as the latter is very mobile nutrient and readily redistributes to parts where it is needed most (Tuskerman 1983).

Remobilization of K between CSG and PVP

Potassium content of PVP increased from 74.3 g/vine to 85.5 g/vine at the end of the first month but decreased to less than half of this quantity by the 4th month (Table 1). Potassium content in the CSG was 15.7 g/vine after 2 months of growth which gradually decreased to 7.1 g/vine at the end of the seasonal growth. Perennial vine parts gained 43.76 g/vine of K whereas CSG gained 15.67 g/vine (Table 2). In the case of K also PVP could meet the entire requirement of CSG though there was no net loss of K from PVP. There was considerable movement of K from CSG to PVP (8.60 g/vine) at the end of the seasonal growth. This conforms to the observation of Wilkinson and Perring (1964) in apple. As in the case of N, potassium absorbed later in the season was stored in PVP since CSG had already entered the

senescent stage.

In south India, grape is subjected to pruning twice in a year. After each pruning, the vine loses all its photosynthetic surface and for the development of new buds the vine have to fall back on the reserves of carbohydrates, sugars and mineral nutrients. As seen in this study, stored nutrients in PVP played an important role in meeting the immediate needs of CSG. In contrast to this picture of a declining vine under stress, the quantity of nutrients in a healthy vine involved in the 'turnover' may be much higher due to absorption of higher quantity of nutrients from native and exogenous sources in soil. When a vine carries a 'crop load' this picture may undergo further changes. More detailed studies are required to obtain a complete idea of the dynamics of nutrients between CSG and PVP by using healthy and productive vines of grape.

SUMMARY

An experiment was conducted during 1996 to quantify the movement of nutrients from perennial vine parts (PVP) to current season growth (CSG) through nutrient redistribution following forward pruning in 'Thompson Seedless' grape (*Vitis vinifera* L.) vines which were under declining condition. Vines were destructively sampled at pruning and at subsequent monthly intervals and the biomass and N, P and K contents were determined to monitor the movement of nutrients from one part to the other. The results indicated that the entire energy (carbohydrates that constitute dry matter), N, P and K requirement of CSG was met by the reserves of PVP. However, at the time of senescence, 39.4 and 19.6% of P and K was remobilized from CSG to PVP.

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Table 2 Net gain and loss of biomass, nitrogen, phosphorus and potassium (g/vine) in current season growth (CSG) and perennial vine parts (PVP) in 'Thompson Seedless' grape in growth succeeding forward pruning

Component	CSG		PVP	
	Gain	Loss	Gain	Loss
Biomass	1 416	74	2 827	
Nitrogen	17.19	5.18		5.17
Phosphorus	3.35	1.48	3.76	4.41
Potassium	15.67	8.57	43.76	

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Comparative utilization of lignocellulosic components of paddy straw by *Tricholoma lobayense* and *Volvariella volvacea**

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Key words: *Tricholoma lobayense*, *Volvariella volvacea*, lignin, cellulose, hemicellulose, laccase, cellulase, chitin

In straw and other lignocellulosic wastes used for cultivation of *Tricholoma lobayense* and *Volvariella volvacea*, the major nutrients are cellulose, hemicellulose and lignin. Degradation of these carbon sources and production of laccase and cellulase by the two mushroom fungi at different stages of spawn run and fructification are reported in this study.

Paddy straw was separately inoculated with *T. lobayense* and *V. volvacea* and the samples of colonised substrate were taken at different stages of spawn run and cropping.

The percentage of lignin in the samples was determined following the method of Effland (1977) and holocellulose and -cellulose according to method of Sengupta *et al.* (1958).

For determination of mycelium content of colonised substrate, at first the mushroom fungi were grown in liquid medium and the chitin content of the mycelia was determined by the method of Ride and Drysdale (1972). The two fungi *T. lobayense* and *V. volvacea* were found to contain 1.65 and 1.70 % glucosamine on dry weight basis. Chitin content of the colonised substrate was also determined following the above method. As the chitin content of the mycelia of *T. lobayense* and *V. volvacea* were known, it was possible to determine the amount of mycelium present in 100 g colonised substrate from its total chitin content.

The cellulase and laccase activity in the colonised substrate were assayed according to Mandel *et al.* (1974) and Sandhu *et al.* (1983).

In case of *T. lobayense* (Table-1) utilisation of lignin was relatively high up to 20 day, when the spawn run was over. Afterwards, up to 25 days, ie during pine initiation and fruiting stage, the rate of utilization was lower. Utilization of cellulose and hemicellulose, however, was lower in spawn run phase (up to 20 day), but higher afterwards.

However, in case of *V. volvacea* (Table 1) there was no lignin utilization throughout the stages of spawn run, pin

formation and cropping. But utilization of cellulose and hemicellulose was gradual during spawn run phase and cropping.

In case of *T. lobayense* (Table 2) the activity of cellulase was low during spawn run (up to 20 day) and thereafter increased. But in case of laccase, the condition was just the reverse. The activity was high during spawn run thereafter it decreased. In case of *V. volvacea* (Table 2) the activity of cellulase increased up to 11 day during spawn run phase, whenafter it started receding. There was no laccase activity at any stage of spawn run and cropping.

Both the enzyme laccase and cellulase were present in *T. lobayense* (Table 3) and hence this fungus could utilize both lignin, cellulose and hemicellulose efficiently and the colonisation of substrate was high. In case of *V. volvacea*, due to the absence of the enzyme laccase this fungus could not utilize lignin so the rate of colonisation at the end of first flush was also poor.

Tricholoma lobayense was found to degrade lignin more actively till the end of spawn run phase, thus increasing the scope for attacking exposed cellulose. During the phase of fructification, degradation of cellulose and hemicellulose became more active. In this mushroom fungus, a good positive correlation was found to exist between lignin degradation and production of laccase as found by Platt *et al.* (1985).

Volvariella volvacea, on the other hand, was found to utilize cellulose and hemicellulose throughout spawn run and cropping phases, but was unable to utilize lignin at any stage. The fungus was found to lack of lignolytic system and hence the fungus access to cellulose and hemicellulose would be restricted. Consequently for *V. volvacea*, rice straw which is relatively rich in lignin (24%) besides containing cellulose (35.5%) and hemicellulose (24.2%) (Rajarithanam *et al.* 1997) is not a suitable substrate for growth and colonisation.

The investigation also shows that content of mycelium in the substrate and yield at the end of first flush in the case of the two mushroom fungi *T. lobayense* and *V. volvacea* were directly correlated with their capacity for utilization of the substrate components (lignin, cellulose and

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Table 1 Utilization of lignin, cellulose and hemicellulose in the substrate by both *Tricholoma lobayense* and *Volvariella volvacea* at different stages of spawn run and fructification

Complex carbon source	Stages of spawn run and fructification									
	1-5 days		6-10 days		11-15 days		16-20 days		21-25 days	
	<i>T. lobayense</i>	<i>V. volvacea</i>	<i>T. lobayense</i>	<i>V. volvacea</i>	<i>T. lobayense</i>	<i>V. volvacea</i>	<i>T. lobayense</i>	<i>V. volvacea</i>	<i>T. lobayense</i>	<i>V. volvacea</i>
Lignin	0.26	0.00	0.54	0.00	0.60	0.00	0.66	0.00	0.29	
Cellulose	2.73	0.21	3.68	2.21	4.38	5.8	6.98	4.72	7.08	
Hemicellulose	0.19	0.55	1.78	2.18	3.24	6.2	4.52	6.52	5.28	

Data are average of five separate determinations

Table 2 Activities^a of laccase and cellulase by *Tricholoma lobayense* and *Volvariella volvacea* at different stages of spawn run and fructification

Enzyme	Stages of spawn run and fructification											
	0 day		5 days		10 days		15 days		20 days		25 days	
	<i>T. lobayense</i>	<i>V. volvacea</i>	<i>T. lobayense</i>	<i>V. volvacea</i>	<i>T. lobayense</i>	<i>V. volvacea</i>	<i>T. lobayense</i>	<i>V. volvacea</i>	<i>T. lobayense</i>	<i>V. volvacea</i>	<i>T. lobayense</i>	<i>V. volvacea</i>
Laccase	0.00	0.00	0.06	0.00	0.14	0.00	0.19	0.00	0.24		0.06	
Cellulase	0.00	0.00	0.07	0.17	0.09	0.19	0.18	0.05	0.57		0.59	

^aActivities expressed as unit in relative terms of absorbance

Table 3 Comparative utilization of substrate component, hydrolytic enzyme activity, colonisation of substrate and yield of *Tricholoma lobayense* and *Volvariella volvacea* at the end of first flush

Mushroom fungi	Utilization of substrate component (100 g of dry substrate)			Hydrolytic enzyme		Colonisation of substrate (g mycelium / 100 g substrate) at the end of first flush	Yield (g) per kg of substrate at the end of first flush
	Lignin	Cellulose	Hemicellulose	Laccase	Cellulose		
<i>T. lobayense</i>	0.29	7.08	5.28	0.06	0.59	7.99	650
<i>V. volvacea</i>	0.00	4.82	5.72	0.00	0.05	5.91	147

hemicellulose) based on their capacity to produce the hydrolytic enzymes (laccase and cellulase). As *V. volvacea* was found to be poor coloniser of substrate because of less efficient hydrolytic enzyme system, the production of fruit bodies per unit quantity of substrate was also less. On the other hand, *T. lobayense* was more efficient coloniser of the substrates because of more active hydrolytic enzyme system. Consequently productivity in the substrate was also much higher.

SUMMARY

An experiment was conducted to study comparative utilization of lignocellulosic components of paddy straw by

Tricholoma lobayense and *Volvariella volvacea*. The *T. lobayense* degraded the lignin more actively till the end of spawn run phase. However, *V. volvacea* could utilize cellulose and hemicellulose throughout spawn run and cropping phases, but was unable to utilize lignin at any stage.

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Response of sugarcane (*Saccharum species*) hybrid complex to planting seasons and nitrogen levels*

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Key words: sugarcane, planting seasons, intercropping, paired row planting, cane equivalent yield

The yield performance of different sugarcane genotypes in subtropical India depends on planting seasons and input management. Autumn planting has been reported as superior to spring and summer plantings. (Singh *et al.* 1990, Verma *et al.* 1996). Autumn planted sugarcane being a long duration and widely spaced crop provide ample scope for intercropping. Thus intercropping of sugarcane with different crops, viz potato, mustard, wheat and toria is in practice to improve resource use efficiency and generate income through diversified production.

Sugarcane crop requires 112 to 400 kg nitrogen/ha in subtropical to tropical climatic conditions of India varying with soil type and duration of the crop (Yadav *et al.* 1988). Nitrogen being the expensive input in sugarcane cultivation, needs to be used judiciously to improve plant growth, development and yield.

The field experiment was conducted at the experimental farm of Indian Institute of Sugarcane Research, Lucknow during 1995-97 and 1996-98 to evaluate the yield performance of 3 sugarcane genotypes, viz 'CoS 90269' (V₁), 'CoPant 90223' (V₂) and 'CoS 86218' (V₃), with and without intercropping as well as nitrogen doses. Planting seasons treatment were autumn (October) sole cane (T₁); autumn cane + mustard (T₂), spring (February) sole cane (T₃) and summer (April) sole cane (T₄) under three levels of nitrogen, viz 112.5 kg N/ha (N₁), 150 kg N/ha (N₂) and 187.5 kg N/ha (N₃). The soil of the experimental field was clay loam with low available N, medium phosphorus and potassium contents. The pH of the soil was 7.80.

Recommended spacing of 90 cm from row to row was adopted in planting of sugarcane. In autumn season only mustard ('Varuna') was intercropped (1:1 row arrangement) with sugarcane and in spring and summer seasons, paired row planting technique (30:60 cm) was adopted. A dose of 60 and 40 kg P and K/ha was applied to sugarcane. In the treatment T₂, where mustard was inter cropped with sugarcane an additional dose of 80, 40 and 40 kg NPK/ha was also applied. Thus, the experiment consisted of 36

treatments and 3 replications were laid down in split plot design keeping combinations of genotypes and planting seasons in main plots and nitrogen levels in sub plots.

Tillers were counted on first day of each month from March to August and data were recorded in 1 000 tillers / ha. Observations were recorded at the time of harvest on milleable canes /ha, cane length (cm), cane diameter (cm), cane weight (g/cane), mustard yield (tonnes/ha) and cane yield (tonnes/ha) (Table 1). Juice quality was also analysed with brix (%), pol (%), purity (%) and CCS (%) and presented in Table 2. Statistical analysis was done in split plot design.

Sugarcane equivalent yield was calculated on the prevalent market price of mustard @ Rs 1 200/100 kg in the first year and Rs 1 300/100 kg in the second year and sugarcane was priced @ Rs 74/tonne. Autumn crop was harvested in the month of January at the age of 15 month whereas spring and summer crops were harvested at the age of 12 months.

Results obtained under the influence of genotypes, planting seasons and nitrogen levels are discussed in the forthcoming paragraphs.

Genotypes

Analysis of tillering pattern (Fig 1) indicated a rise in the tiller number from march to July and decline in the month of August. This decline could be attributed to the facts of intertiller competition and survival for the fittest.

These findings are in conformity with the results obtained by Soopramanien and Julian (1980) and Shukla *et al.* (1998). 'CoPant 90223' recorded highest number of tillers in almost all the observations. On the contrary 'CoS 90269' recorded lowest tillering.

A significant difference in milleable canes/ha, cane diameter, cane weight cane yield, cane equivalent yield (Table 1) and pol %, purity and CCS % (Table 2) was recorded due to the difference in genotype. In almost all the observations, 'CoPant 90223' recorded highest value.

Planting seasons

Planting seasons also influenced tillering considerably. Spring planted sugarcane recorded highest number of tillers from May to August. Mortality of tillers was high in autumn

*Short note

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Table 1 Mean cane growth and yield as influenced by different treatments during both the cropping seasons

Treatment	Millable canes ('000/ha)	Cane length (cm)	Cane diameter (cm)	Cane weight (g/cane)	Mustard yield (tonnes)	Cane yield (tonnes/ha)	Cane equivalent yield (tonnes/ha)	CCS equivalent yield (tonnes/ha)
<i>Genotypes</i>								
V ₁ 'CoS 90269'	137.6	180.4	2.27	642.7	1.466	57.65	82.06	10.37
V ₂ 'CoPant 90223'	143.3	195.3	2.23	707.4	1.485	75.48	100.68	13.17
V ₃ 'CoS 86218'	139.5	166.3	1.82	629.0	1.289	64.10	86.06	11.04
CD (P=0.05)	5.26	7.35	0.09	48.01	NS	2.35	3.60	0.54
<i>Planting seasons</i>								
T ₁ Autumn cane (Sole)	119.0	193.1	2.39	796.4		77.85	77.85	9.46
T ₂ Autumn cane + mustard	112.5	198.2	2.20	676.2		70.01	94.02	11.56
T ₃ Spring cane	167.9	174.2	1.96	565.0		62.65	65.65	8.17
T ₄ Summer cane	162.7	157.8	1.87	551.3		52.46	52.46	6.91
CD(P=0.05)	6.08	8.47	0.10	73.78		2.73	4.70	0.68
<i>Nitrogen Levels (kg/ha)</i>								
N ₁ 112.5	134.4	173.6	1.98	591.8	1.206	61.2	81.67	10.34
N ₂ 150	141.3	180.7	2.11	655.4	1.448	65.8	90.40	11.46
N ₃ 187.5	145.7	188.1	2.23	731.7	1.587	72.2	96.00	12.22
CD(P=0.05)	2.92	1.40	0.014	21.06	0.169	0.52	1.60	0.32

Table 2 Juice quality of sugarcane as influenced by genotypes, planting seasons and nitrogen levels

Treatment	Juice brix (%)	Pol percent juice	Juice purity (%)	CCS (%) in cane
<i>Genotypes</i>				
V ₁ 'CoS 90269'	20.20	19.32	95.64	13.85
V ₂ 'Co Pant 90223'	19.91	17.93	90.00	12.51
V ₃ 'CoS 86218'	20.18	18.32	90.78	12.83
CD (P=0.05)	NS	0.47	2.23	0.36
<i>Planting seasons</i>				
T ₁ Autumn cane (sole)	18.53	17.24	93.03	12.20
T ₂ Autumn cane + mustard	18.80	17.41	92.60	12.30
T ₃ Spring cane	20.91	18.73	89.75	13.02
T ₄ Summer cane	22.07	19.18	86.90	13.16
CD (P=0.05)	0.68	0.55	2.58	0.42
<i>Nitrogen Level (kg/ha)</i>				
N ₁ 112.5	20.19	18.19	90.09	12.69
N ₂ 150	20.14	18.17	90.22	12.69
N ₃ 187.5	20.03	18.07	90.21	12.61
CD (P=0.05)	NS	NS	NS	NS

planted sugarcane with and without mustard.

Significant influence of planting season was recorded in millable canes, cane length, cane diameter, cane weight and cane yield (Table 1), brix %, pol %, purity and CCS % (Table 2).

Autumn cane (sole) produced higher number of millable canes (119.0 thousand/ha) as compared to intercropped cane. Autumn cane produced longer cane than spring and summer seasons. Higher cane diameter and weight was recorded in autumn season as compared to spring and summer seasons. It was due to longer time available to autumn planted crop for tillering and growth which encouraged length, diameter and cane weight. Highest cane equivalent and CCS equivalent yield was obtained with intercropping of mustard with autumn

sugarcane. Although autumn crop produced lesser number of millable canes as compared to spring cane but due to higher cane length and weight it produced higher yield than spring and summer seasons. The superiority of autumn crop over spring and summer planted crop has also been established by other research workers (Singh *et al.* 1990, IISR 1994).

Spring and summer crop showed higher values of juice brix and pol per cent juice. It was due to higher temperature at the time of harvesting of spring and summer crops which concentrated juice and reflected higher values. Juice of autumn sugarcane was purer than spring and summer crops. Commercial cane sugar (%) was higher with spring and summer crops as compared to autumn (sole) and intercropped sugarcane.

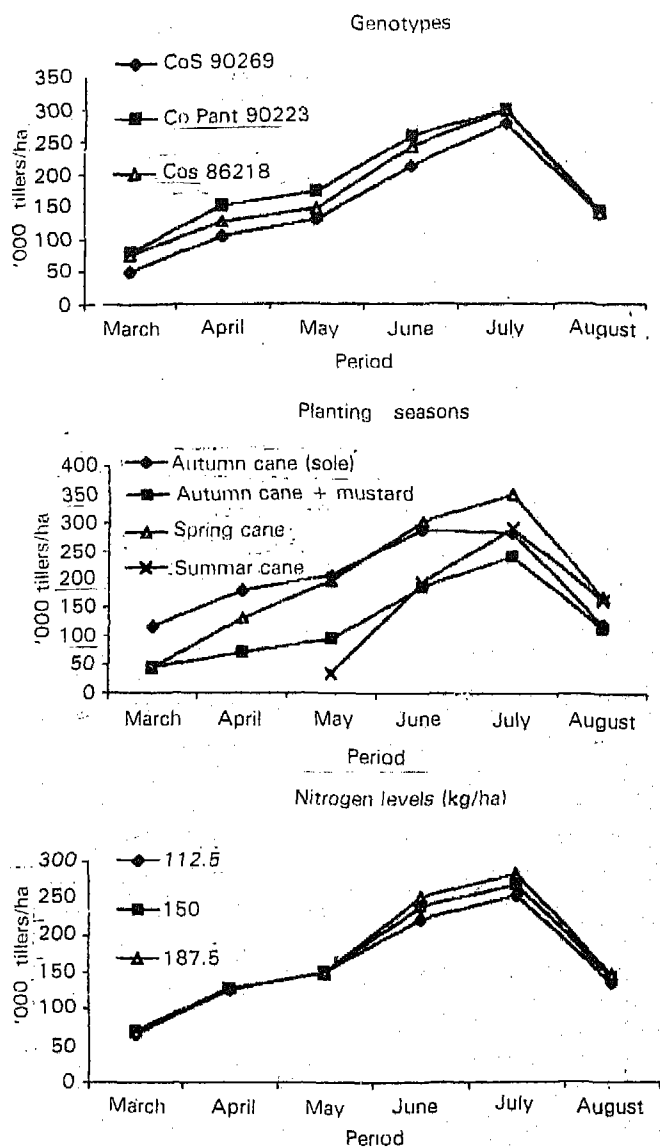


Fig 1 Mean number of tillers as influenced by different treatments during 1995-97 and 1996-98

Nitrogen levels

Tiller number increased with the increase in the dose of nitrogen (Fig 1). Nitrogen levels significantly influenced the millable canes, cane length, cane equivalent yield and CCS equivalent yield. Values recorded were highest at 187.5 kg N/ha. These results are comparable to those reported by Bhoj (1962), Mahadevswamy (1997) and Kumaraswamy and Rajasekaran (1994). Cane juice quality remains unaffected

with increasing nitrogen levels up to 187.5 kg N/ha.

Thus intercropping of sugarcane genotype 'CoPant 90223' with mustard ('Varuna') under application of 187.5 kg N/ha was found one of the best treatment combinations tried in the investigation.

SUMMARY

A field experiment was conducted for two consecutive cropping seasons (1995-97 and 1996-98) to evaluate the performance of 3 sugarcane genotypes ('CoS 90269', 'CoPant 90223' and 'CoS 86218') in autumn, spring and summer seasons at 3 nitrogen levels (112.5, 150 and 187.5 kg N/ha). Genotype, 'CoPant 90223' produced significantly higher number of millable canes (143.3 thousand/ha) as compared to 'CoS 86218' and 'CoS 90269'. Cane length and diameter of autumn crop were higher than spring and summer crops. Genotype, 'CoPant 90223' produced maximum cane yield (75.48 tonnes/ha), cane equivalent yield (100.68 tonnes/ha) and CCS equivalent yield (13.17 tonnes/ha). Intercropping of mustard with autumn sugarcane showed highest yield values. Increasing nitrogen levels increased cane growth and yield significantly but did not affect juice quality (brix, pol and purity).

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Effect of pan evaporation based irrigation scheduling on yield and quality of drip irrigated Nagpur mandarin (*Citrus reticulata*)*

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Key words: drip irrigation, pan evaporation, Nagpur mandarin, *Citrus reticulata*, irrigation scheduling

Nagpur mandarin (*Citrus reticulata* Blanco) is one of the important citrus fruit crop grown in Central India occupying 40 % of the total area under citrus cultivation. Irrigation to the plants is an important operation which affect the mandarin production. One of the reasons for low mandarin yield is adoption of surface gravity irrigation methods and schedule of irrigation on calendar basis, which makes excess use of available water resources. The scheduling of irrigation adopted in orchard, affect availability of soil moisture to the plants and its distribution in the soil, fertilizer application method and nutrient uptake. In citriculture drip irrigation scheduling is getting popularity due to better water use efficiency in addition to other advantages. Except the system cost the advantages includes saving in labours, water and power, greater orchard uniformity, immediate response to crop need, better soil-water-plant relationship, rooting environment and better yield and quality. Sanehez *et al.* (1989) compared five flood irrigation treatments with daily drip irrigation at 0.475 Epan and concluded that the drip irrigation gave higher yields as compared to flood irrigated plants. Gangwar *et al.* (1997) studied the economics of investment on adoption of drip irrigation system in Nagpur mandarin orchards in central India and concluded that the drip irrigation system is technically feasible and economically viable with benefit to cost ratio as 2.07.

The water requirement of citrus plants varies with species, season and age under different climatic conditions. Plant growth retards below certain critical level of available moisture depending upon soil type, climatic factor and plant genetic make up. Irrigation scheduling based on depletion of available water content as 65% (Toledo 1982) in Valencia, 40-100% (Moreshet *et al.* 1983) in 'Shamouti' orange and 85 % (Peres 1987) in Valencia have been suggested. Field experiment with a mature 'Valencia' orange trees showed that the water use pattern over the entire season reached a maximum of 87 day in January. The highest yields (190 kg/

tree) and the largest average fruit size with irrigation at a crop factor of 0.9 on a 3 day cycle was obtained (Plessis 1988). Castel and Buj (1990) observed that mature 'Satsuma' trees grafted on Sour orange rootstocks showed a good response in yield and quality when irrigated with 60% of the estimated ET losses from a class A pan and 80% of the control throughout the year. In a recent study on irrigation scheduling based on open pan evaporation in acid lime in pre-bearing stage found that the evapotranspiration varied from 213.6 mm to 875.6 mm in various irrigation schedules. Moreover, the change in soil-moisture distribution in the root zone of acid lime plants varied from 195.9 mm to 321.3 mm with different irrigation schedules(Shirgure *et al.* 2000). The objective of this study was to find out optimum pan evaporation for irrigation scheduling in Nagpur mandarin under drip irrigation system.

To study the irrigation scheduling and water requirement based on open pan evaporation through the drip irrigation in five years old Nagpur mandarin a field experiment was conducted in the block of 72 × 72 m with 6 × 6 m spacing at experimental farm of NRC for Citrus, Nagpur. The treatments were irrigation equivalent to 0.6 of open pan evaporation (I_1), irrigation equivalent to 0.7 of open pan evaporation (I_2), irrigation equivalent to 0.8 of open pan evaporation (I_3) and irrigation equivalent to 0.9 of open pan evaporation (I_4) with six replications in randomized block design. The average soil depth was 55 cm. The field capacity and permanent wilting point was observed as 28.2% and 17.6% respectively with available water content of 10.6%. The irrigation was scheduled on open pan evaporation.

Based on the average monthly open pan evaporation, the irrigation quantities were calculated taking into account of pan factor (0.7), canopy factor (0.4) and crop factor (0.6). Monthly quantity of irrigation given was recorded from April to March (Table 1). Soil-water measurements were taken up daily during April 1998 to March 2000 with the help of a neutron moisture probe which was calibrated against gravimetric sampling for this particular field having the following calibration equation $y = 0.023 x + 0.12$ ($r=0.96$), where y, ratio of actual count to standard counts; and x, soil-

* Short note

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Table 1 Quantity of water application in different irrigation schedules during 1998-99 and 1999-2000

Treatments	Monthly total depth of irrigation applied (litres / day)									
	Year	Apr	May	Jun	Jul-Oct	Nov	Dec	Jan*	Feb	Mar
I ₁	1998	52	53	22	R	15	11	12	22	35
	1999	55	43	24	R	18	14	16	18	33
I ₂	1998	61	60	25	R	17	13	14	25	41
	1999	64	50	27	R	20	17	19	21	39
I ₃	1998	70	68	29	R	20	15	16	29	47
	1999	73	57	31	R	23	19	21	24	44
I ₄	1998	74	75	32	R	22	17	18	32	52
	1999	82	64	35	R	26	21	23	26	50

*A 15 days stress was given for flower induction during first fortnight of January, R - rainfall period

Table 2 Growth parameters and leaf nutrient composition of Nagpur mandarin as affected by irrigation schedules

Treatments	Plant height (m)	Stock girth (cm)	Canopy volume (m ³)	Leaf nutrient composition (%)		
				N	P	P
I ₁	0.70	8.10	1.96	1.72	0.08	1.68
I ₂	0.71	9.47	1.99	1.92	0.10	1.72
I ₃	0.74	9.89	2.12	2.24	0.12	1.92
I ₄	0.71	9.23	2.10	1.98	0.10	1.73
CD (P=0.05)	NS	NS	0.02	0.10	NS	0.08

Table 3 Effect of irrigation schedules on the fruit yield and quality of Nagpur mandarin

Treatment	Fruit yield (kg/tree)	Average fruit weight (g)	TSS (°Brix)	Juice (%)	Acidity (%)
I ₁	8.26	151.00	7.55	41.22	0.66
I ₂	8.91	161.17	7.62	39.96	0.77
I ₃	14.23	167.00	8.23	43.46	0.69
I ₄	10.18	154.33	7.72	40.76	0.77
CD (P=0.05)	4.29	4.92	0.48	1.88	NS

moisture content (volume basis). Aluminum access tubes were inserted to the depth of 70 cm within the tree basin and 70 cm apart from the trunk in between the two emitters. The depth and quantity of irrigation water was recorded. The vegetative growth parameters of Nagpur mandarin plants (plant height and tree spread) were recorded in October 1998 and 1999. The plant girth was taken 15 cm above the soil surface. The canopy volume of the mandarin tree was calculated according to formula suggested by Castle (1983). Nagpur mandarin fruit yield was recorded. Quality analysis was also carried out as per procedures described by Ranganna (1988). Leaf samples were collected as per procedures suggested by Srivastava *et al.* (1994) and finally prepared samples were digested in diacid mixture of H₂SO₄: HClO₄ in

2.5:1 ratio. The leaf N was determined using alkaline permanganate steam distillation method, P by vanadomolybdophosphoric acid method and K flame photometrically (Chapman and Pratt 1982).

Irrigation scheduling and soil moisture status

The consumptive use of Nagpur mandarin was estimated under clean cultivation by modified Penman equation using 40 years meteorological data (air temperature, relative humidity, wind velocity and solar radiation). The average irrigation water requirement of Nagpur mandarin per plant varied from 11 to 53 and 14 to 55 litres per day in 0.6 open pan evaporation irrigation scheduling treatment during 1998-99 and 1999-2000 respectively. The water requirement of

Nagpur mandarin plant varied from 13 to 61 and 17 to 64 liters per day in 0.7 open pan evaporation irrigation scheduling treatment during 1998–99 and 1999–2000 respectively. The same was varied from 15 to 70 and 19 to 73 liters per day in 0.8 open pan evaporation irrigation scheduling treatment during 1998–99 and 1999–2000 respectively. In case of 0.9 pan evaporation irrigation scheduling treatment average water required ranged from 17 to 75 and 21 to 82 liters per day during 1998–99 and 1999–2000 respectively.

Soil moisture content at various dates during the entire growth period was observed. The soil moisture content varied from 27.0 to 40.7% in irrigation at 0.6 open pan evaporation, 27.8 to 42.4% in irrigation at 0.7 open pan evaporation, 27.9 to 41.7% in irrigation at 0.8 open pan evaporation and 28.0 to 42.4% in irrigation at 0.9 open pan evaporation scheduling respectively.

Growth and leaf nutrient of Nagpur mandarin

The data on growth parameters (Table 2) revealed that out of various growth parameters, only canopy volume produced a significant response in relation to irrigation treatments. The highest increase in canopy volume (2.12 m³) was observed with irrigation equivalent to 0.8 open pan evaporation as compared to rest of the treatments. The highest leaf N (2.24%) and K (1.92%) was registered with irrigation equivalent to 0.8 open pan evaporation, which was significantly higher than that of 0.6 open pan evaporation (1.72% N and 1.68% K), 0.7 open pan evaporation (1.92% N, and 1.72% K) and 0.9 open pan evaporation (1.98% N and 1.73% K). However, treatments had no significant effect on the leaf P contents (Table 2).

Fruit yield and quality

Fruit yield and quality of Nagpur mandarin was significantly affected by different irrigation treatments (Table 3). The highest fruit yield (14.23 kg/tree) was recorded with irrigation equivalent to 0.8 open pan evaporation, which was at par with that of 0.9 open pan evaporation (14.18 kg/tree). Out of different quality parameters, fruit weight, TSS, juice content and acidity were observed to be significantly affected by irrigation schedules. Highest fruit weight (167.00 g), TSS (8.23%) and juice content (43.46%) was observed with 0.8 open pan evaporation which suggested superiority of the 0.8 open pan evaporation over other treatments.

SUMMARY

The irrigation requirement using drip irrigation system in Nagpur mandarin scheduled at 0.8 of pan evaporation ranged from 15 to 73 litres during 1998–2000. The

incremental growth of plant height, girth and canopy volume was more in irrigation scheduled at 0.8 of open pan evaporation. Due to optimum water regime the irrigation scheduled at 0.8 of open pan evaporation gave better growth of Nagpur mandarin. Average fruit yield of 14.23 kg per tree, fruit weight of 167 g and juice of 43.46% were recorded in 0.8 of pan evaporation irrigation schedule. Acidity of Nagpur mandarin was more in irrigation schedules 0.7 and 0.9 of open pan evaporation. This study indicated that the growth, yield and fruit quality of Nagpur mandarin with 0.8 of open pan evaporation irrigation scheduling was better using drip irrigation system.

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Sulphur deficiency effects on metabolism and seed quality of maize (*Zea mays*) and recovery therefrom*

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Key words: maize, *Zea mays*, S deficiency, enzymes, seed quality

For higher plants, the practical importance of sulphur in recent years is being realised as sulphur application under field condition has not only resulted in boosting the economic yield but also in improving its quality (Tandon 1991). The incidences of sulphur deficiency have been reported from more than 70 countries (Schung *et al.* 1995).

Sulphur as a secondary nutrient is an essential component of amino acids, proteins, vitamins and precursor of many sulphur containing compounds such as co-enzymes and secondary plant products (Marschner 1995). Sulphur is involved in light reaction of photosynthesis as an integral part of ferredoxin, a non-haem iron sulphur protein (Marschner 1995). In several plant species sulphur deficiency is known to decrease chlorophyll content of leaves and as a result indirectly affects photosynthesis (Dietz 1989). In many legumes and Brassicaceae visible symptoms of sulphur deficiency remain indistinguishable (Bansal 1992) and therefore diagnosis of sulphur deficiency on the basis of visible effects is rather difficult. In cereals, the quality of produce is lowered by sulphur deficiency as the major storage sulphur rich proteins, such as glutelin, is reduced and the proportion of zein protein (a low sulphur protein) increases in maize (*Zea mays* L.) (Randall and Wrigley 1986). The lower sulphur content of proteins influences nutritional quality of grains eg methionine, one of the sulphur containing amino acids in human nutrition and often a limiting factor, in diet is lowered (Mengel and Kirkby 1987) and also a decrease in cysteine content in low sulphur cereal grains reduces the baking quality of flour (Marschner 1995). A close relationship has been observed in the content of glucosinolates and their volatile metabolites with sulphate supply affecting the taste of vegetables and oil content in oil crops.

In the present study, observations have been made on the changes in reproduction and maize metabolism by sulphur deficiency and recovery therefrom. Apart from this, whether withdrawal of sulphur from the medium is responsible in maize, for recurrence of deficiency effects or not has also

been established.

The experiment was conducted in glass-house in two consequent *kharif* seasons (1998-99) at Botany Department, Lucknow University, Lucknow. Maize, cv 'Ganga 2' was grown in purified sand in plastic containers (5l capacity). The method of growing plants in refined sand and composition of nutrient solution was the same as described earlier (Khurana *et al.* 1999). Sulphur was supplied separately as sodium sulphate at 4 levels, viz 0.02, 0.5, 2 and 4 mM, ranging from acute deficiency to excess, with 4 replications at each level. The composition of the nutrient solution, excluding sulphur, was the same as described elsewhere (Khurana *et al.* 1999). Contribution of sulphur from micronutrients in the form of sulphate was less than 0.01mM, which was taken into consideration.

Apart from recording visible symptoms of sulphur deficiency, dry matter of plants was determined (day 56) after drying the washed fresh plant material in oven at 70°C. The dried leaves were weighed and digested in nitric-perchloric acids (10:1) and in the clear digest sulphur and phosphorus concentrations were estimated as described elsewhere (Dube *et al.* 2000). Hill reaction activity in leaves (60 days after sowing) and the activity of enzymes catalase, peroxidase, acid phosphatase and starch phosphorylase were assayed in crude leaf extract at day 51 (Khurana *et al.* 1999).

After 57 days, with the intensification of sulphur deficiency symptoms and on the emergence of inflorescence, 2 pots containing sulphur - deficient plants (0.02 and 0.5 mM) were supplied with additional sulphur (2 mM) and at the same time sulphur was withdrawn from those pots containing plants supplied with sufficient sulphur (2 and 4 mM). Both the treatments were continued for a fortnight. At day 72, plants from all treatments were sampled for dry weight, economic yield and determination of sulphur and phosphorus concentrations in leaves and seeds of maize. On the same day (day 72), young leaves were also assayed for the activity of catalase, peroxidase, acid phosphatase and starch phosphorylase according to the method described elsewhere (Khurana *et al.* 1999). Apart from this, in seeds (at day 72), the estimation of sugars, starch, phenols and

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Table 1 Variable sulphur and dry weight, sulphur and phosphorus concentration (day 56), Hill reaction activity (day 60) and specific activity of some enzymes in maize leaves

Sulphur (mM)	Dry matter yield (g/plant)	S concentration (% in dry matter)	P concentration (% in dry matter)	Hill reaction activity (ΔOD)/100 mg fresh weight	Catalase (moles H_2O_2 decomposed)	Peroxi-dase (ΔOD)	Acid phosphatase (g Pi liberated)	Starch phosphorylase (g Pi liberated)
0.02	8.7	0.9	0.30	0.125	131	1.51	37.50	8.99
0.5	56.7	0.14	0.30	0.375	200	1.48	25.04	12.5
2	61.1	0.20	0.22	0.700	210	1.42	22.30	14.4
4	67.0	0.30	0.29	0.880	254	1.48	31.80	9.9
LSD ($P=0.05$)	2.8	0.04	0.08	0.055	12	0.60	5.00	2.6

total protein content was made according to Khurana *et al.* (1999) and that of nitrogen fractions were also estimated (Chatterjee *et al.* 1992). The entire data were subjected to statistical analysis and tested for significance at $P=0.05$.

At day 21–25, acute sulphur deficiency depressed the growth and induced chlorosis in young leaves of maize when grown in refined sand. Later chlorosis intensified and covered the entire lamina which become bleached and papery. Purple pigments developed near the margins of affected leaves, which gradually covered the stem with short internodes. The entire foliage were highly reduced in size and further growth of plants was checked at 0.02 mM. These symptoms of low sulphur were less pronounced at 0.5 mM sulphur due to mild deficiency. These visible symptoms of low sulphur were similar to those described by Tandon (1995) and Laurent *et al.* (1992) for many cereals.

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Almost no cobs were produced in acute sulphur deficiency and in latent sulphur deficiency only one malformed, less developed with few deformed seeded cobs were produced. This might substantiate an essential role of sulphur not only in increasing vegetative growth but also in the development of reproductive parts. The biomass, cob and seed yield in maize were maximum at a level double of the optimum

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The significant decrease in the concentration of sugars in sulphur deficient seeds of maize as a result of low sulphur is in accord with the earlier results on maize (Rendig *et al.* 1976). Low starch content in sulphur - deficient seeds of maize is similar to the findings of Munshi *et al.* (1990) in mustard. This might be ascribed to the reduced activity of starch phosphorylase or other related enzymes of starch synthesis in low sulphur conditions (Marschner 1995). Accumulation of phenols in seeds from sulphur-deficient maize plants might be the consequence of higher peroxidase activity or inhibition in protein synthesis (Mortensen *et al.* 1993) under such conditions, ultimately leading to the deterioration of seed quality.

In maize seeds, the lowering of protein nitrogen and accumulation of non-protein nitrogen in low sulphur impairs the protein synthesis which might be correlated with an accumulation of soluble organic nitrogen and nitrates (Karmaker *et al.* 1991) resulting in the formation of low sulphur containing proteins in such conditions.

Table 2 Effect of sulphur addition and withdrawal on dry weight, weight of cobs, concentrations of sulphur and phosphorus and specific activity of catalase, peroxidase, acid phosphatase and starch phosphorylase in maize leaves deficient and sufficient in sulphur

Sulphur (mM)	Dry matter yield (g/plant)	Weight cobs (g/plant)	S concentration (% in dry matter)	P concentration (% in dry matter)	Catalase (μ moles H_2O_2 decomposed)	Peroxi-dase (ΔOD)	Acid phosphatase (μg Pi liberated)	Starch phosphorylase (μg Pi liberated)
0.02	22.0	1.56	0.10	0.40	132	1.48	22.04	6.2
0.02 + 2	28.2	4.16	1.17	0.33	211	1.33	17.96	9.7
0.5	137.6	36.4	0.30	0.40	278	1.39	25.00	21.9
0.5 + 2	151.4	42.1	0.43	0.19	301	1.12	24.39	24.6
2	148.5	52.0	0.37	0.27	234	1.44	29.23	25.0
2 - S	110.1	34.5	0.30	0.37	278	1.50	28.05	19.3
4	166.6	56.7	0.47	0.38	176	1.53	26.56	20.6
4 - S	127.5	36.2	0.40	0.30	262	2.16	23.99	15.0
LSD ($P=0.05$)	5.8	2.5	0.02	0.02	12	0.53	2.98	1.6

In sulphur deficient leaves of maize, the decrease in catalase activity (Tables 1 and 2) can be related to low availability of iron in sulphur deficiency and lowered activity of starch phosphorylase might be due to low starch formation hampering carbohydrate metabolism of maize. The stimulated activity of acid phosphatase (Tables 1 and 2) might explain the accumulation of iP in low sulphur conditions as has been observed earlier for greengram (*Phaseolus radiatus* L.) and onion (*Allium cepa* L.) (Chatterjee *et al.* 1992, 1999).

In maize, low sulphur affected the reproductive yield more pronouncedly than the vegetative yield which was obvious in latent deficiency of sulphur where the reduction in economic yield was 36% of that obtained at supra-normal sulphur supply and the depression in total biomass was only 17% suggesting that the involvement of sulphur is more in the formation of economic yield. No proper cob formation in acute sulphur deficiency also substantiates this observation (Table 1).

The seeds produced in latent sulphur deficiency were malformed, few in number and lighter in weight, low in viability and resulted in lowered seed yield. The seeds were low in sulphur content, protein, starch and sugars and high in phenols, thus affected nutritional quality of the produce as has been observed by Mortensen *et al.* (1993) and Munshi *et al.* (1990).

At the flowering time, addition of adequate sulphur to deficient plants not only increased the biomass of maize but also tried to further the development of reproductive parts. This was apparent when both increased considerably. The increase in cob weight (Table 2) was more pronounced and was 2½ times higher from that obtained at latent sulphur deficiency which might suggest that in low sulphur condition, if the nutrient is supplied through roots even at the time of emergence of inflorescence the incorporation of sulphur is not only faster in sulphur containing constituents of proteins but also that it facilitates the translocation and utilization of

carbohydrates and other nitrogen compounds needed at specific sites for proper metabolism of plant. Resumption of sulphur supply also improved the seed quality by increasing the weight, concentrations of sulphur, total protein, protein nitrogen, starch, sugars and accumulation of phosphorus and lowering the non-protein nitrogen and phenol contents in seeds.

This establishes the essential role of sulphur specially in seed formation. On the other hand, withdrawing sulphur from sufficient plants at the time of flowering partially reversed the characteristics of maize by decreasing the biomass, economic yield, concentration of sulphur in leaves and seeds, starch, sugars, protein nitrogen and total protein contents. This might also reflect that sulphur is required in sufficient amounts throughout the growth period of maize and specially during the development of reproductive parts.

SUMMARY

In maize (*Zea mays* L.) a rudimentary leafy bud in acute (0.02 mM) deficiency and a small malformed cob with few deformed seeds at latent (1 meq S/l) deficiency was produced when plants were raised in refined sand at low sulphur. The resumption of adequate sulphur to deficient (0.02 and 0.5 mM) maize increased the biomass, economic yield, sulphur content, activity of catalase and starch phosphorylase in leaves. In addition, the concentration of reducing and total sugars, starch, protein nitrogen and total proteins also increased in seeds and the phosphorus content, activity of peroxidase and acid phosphatase were reduced in leaves. In seeds the accumulation of non-reducing sugars, non-protein nitrogen and phenols were lowered. On the other hand, withdrawal of sulphur from sufficient maize (2 and 4 mM) decreased the biomass, economic yield, concentration of sulphur and phosphorus in leaves along with a marked reduction in number and weight of seeds per cob and concentration of sugars, starch, protein and non-protein

Table 1 Variable sulphur and dry weight, sulphur and phosphorus concentration (day 56), Hill reaction activity (day 60) and specific activity of some enzymes in maize leaves

Sulphur (mM)	Dry matter yield (g/plant)	S concentration (% in dry matter)	P concentration (% in dry matter)	Hill reaction activity (ΔOD)/100 mg fresh weight	Catalase (moles H_2O_2 decomposed)	Peroxi-dase (ΔOD)	Acid phosphatase (g Pi liberated)	Starch phosphorylase (g Pi liberated)
0.02	8.7	0.9	0.30	0.125	131	1.51	37.50	8.99
0.5	56.7	0.14	0.30	0.375	200	1.48	25.04	12.5
2	61.1	0.20	0.22	0.700	210	1.42	22.30	14.4
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Effect of waterlogging on the growth and yield of summer grown sesame (*Sesamum indicum*)*

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Key words: waterlogging, growth stages, yield, sesame, water balance

Bangladesh has always a deficit of edible oil. Among the oil seed crops, sesame (*Sesamum indicum* L.) is the second largest source of edible oil, covering 14.37% of oilseed cropped area and producing total yield of 49 000 metric tonnes with an average yield of 864.50 kg/ha (BBS, Dhaka 1997). Sesame is extremely susceptible to waterlogging and reported that heavy and continuous rain at any time during growth stages decreases sesame yield (Kaul and Das 1986, BARI 1982-83, 1996-97). So an experiment was conducted in lysimeter during the *kharij-1* (March-July) season at Institute's farm to test and study the waterlogging tolerance limit at different growth stages and its effect on the yield of sesame mutant SM 1, developed by the institute.

The experiment was conducted during March-June 1998. Five lysimeter boxes (each 2 m × 1 m) were used for five waterlogging treatments : no water logging (T_0), 48 hours waterlogging at crop establishment stage [0-10, Days After Emergence (DAE)] (T_1), at vegetative stage (11-36 DAE) (T_2), at flowering and capsule initiation stage (37-60 DAE) (T_3), at seed filling and ripening stage (61-85 DAE) (T_4). The soil of the lysimeter boxes was treated with boric acid powder (10 kg/ha) and was fertilized uniformly with a basal dose of 75 kg/ha N as urea, 35.2 kg/ha P as triple super phosphate and 24.9 kg/ha K as muriate of potash. Sesame seeds were sown on 5 March 1998 and line to line and plant to plant distances were 25 and 5 cm, respectively. Waterlog situation was created by bringing water table on the top of the surface through bottom feeding of the lysimeter system. As per treatment a standing water of 2 cm above the soil surface was maintained. Soil moisture was measured by hydroprobe from 15-120 cm depth for every 15 cm increment. Sesame was harvested on 11 and 16 June 1998. At harvest time, yield and yield attributing data were recorded. Effective rainfall was calculated by FAO method (Brouwer *et al.* 1989). Actual evapotranspiration of sesame mutant was estimated using water balance equation.

From water balance components of sesame mutant, actual

evapotranspiration values were 31.66, 50.12, 46.07, 31.99 and 28.48 cm in T_0 , T_1 , T_2 , T_3 and T_4 treatments, respectively. Actual evapotranspiration was maximum in T_1 treatment and minimum in T_4 treatment, respectively. Actual evapotranspiration values obtained from the experiment were also similar to those obtained by Rao *et al.* (1994).

Effect of waterlogging on sesame plant population is presented in Table 1. Eight per cent sesame plants were lost during the growing season under well drainage condition (T_0 treatment). It is reported that in Venezuela, loss of sesame plants per unit row between 80 and 100 days after sowing was 22% (Mazzami 1966) and in Tanzania, plant loss was found to be between 25-34% (Weiss 1961).

Effect of waterlogging on the yield and yield attributing characters of sesame mutant is presented in Table 2. Maximum plant height was observed under well drainage (T_0 treatment). The 1 000-seed weight was not affected due to waterlogging imposition at different stages of sesame. The seed yield/plant was maximum in T_0 treatment and minimum in T_1 treatment. Minimum seed yield was observed in T_1 treatment, may be due to highest mortality, minimum plant height and number of capsule/plant, respectively. Moreover, it was also observed that after 48 hr waterlogging, the plants became yellowish in colour and continued even waterlogging imposition has been withdrawn. Plants in T_1 , T_2 , T_3 and T_4 treatments were matured earlier compared to T_0 treatment. For this reason, the plants of those treatments were harvested 5 days before than that of T_0 treatment.

Thus sesame mutant SM 1 was very sensitive to waterlogging at crop establishment stage compared to other stages of crop growth. If there is no problem of germination of sesame seed, yield will not be reduced even the crop faces waterlogging for 48 hr in other stages of growth. For better yield of sesame mutant SM 1, seeds may be sown in February/early March to save plants

* Short note

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Table 1 Effect of waterlogging on sesame plant population

Treatments	No. of plants/ plot before waterlogging	No. of plants/ plot after waterlogging	No. of plants at harvest time	Mortality (%) after water- logging	Mortality (%) since water- logging to harvest
T ₀	141	141	130		8
T ₁	138	90	62	35	55
T ₂	88	81	73	8	17
T ₃	73	72	64	1	12
T ₄	132	114	109	14	17

Table 2 Effect of water logging on the yield components of sesame mutant

Treatment	Plant height (cm)	No. of capsules/ plant	No. of seeds/ capsule	1 000- seed weight (g)	Seed yield/ plant (g)	Seed yield/ 2 m ² (g)	Decreasing seed yield/ 2 m ² over control (%)	Straw yield/ 2 m ² (g)	Decreasing straw yield 2 m ² from control (%)
T ₀	120.60	28	55	3.2	4.08	530		905	
T ₁	88.00	23	53	3.7	1.94	120	77.35	200	77.90
T ₂	87.00	24	32	3.0	3.90	285	46.23	480	46.96
T ₃	91.20	33	61	4.0	3.44	220	58.49	620	31.49
T ₄	99.20	31	50	3.5	3.07	335	36.79	640	29.28

from waterlogged condition due to rainfall at crop establishment stage.

SUMMARY

An experiment was conducted during March – June 1998 on silt loam soil in lysimeter to study the effect of waterlogging on the growth and yield of sesame (*Sesamum indicum* L.) mutant (SM 1). The lysimeter where experiment was conducted, provided unique facility for waterlogging imposition. Drainage provisions were made after withdrawal of waterlogging for specified period at different growth stages. Sesame mutant SM 1 was very sensitive to waterlogging at crop establishment stage compared to other stages of growth. A decrease of 47% in seed yield was obtained due to waterlogging at vegetative, flowering and capsule initiation, seed filling and ripening stages, respectively, whereas 77% decrease was obtained at crop establishment stage only. Waterlogging at this stage also severely affected straw yield.

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Influence of white rot (*Sclerotinia sclerotiorum*) on growth and yield parameters of Indian mustard (*Brassica juncea*) varieties*

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Key words: Indian mustard, white rot, *Sclerotinia sclerotiorum*

White rot caused by *Sclerotinia sclerotiorum* (Lib.) de Bary, earlier considered to be a minor disease is now a serious disease of crucifers in some parts of India (Aggarwal *et al.* 1997). The pathogen attacks the host stem at post flowering stage and causes heavy yield losses in Indian mustard (Roy and Saikia 1976). Heavy yield losses due to this disease have also been reported from North -West Haryana (Gupta *et al.* 1994). Since literature on quantitative information on losses is meagre, an attempt was therefore made to study the effect of this disease on the growth and yield contributing characters in Indian mustard [*Brassica juncea* (L.) Czernj & Coss.].

A field experiment was conducted at Bawal with popular Indian mustard varieties ('RH 30', 'RH 8812' and 'T 59') in winter (*rabi*) 1995-96 and 1996-97. The sowing was done in a randomized block design with three replications in plot of 10 m × 5 m. Infected and healthy plants of each variety were tagged for recording observations, viz height, number of primary and secondary branches, siliquae in primary and secondary branches. The seeds were extracted from the siliquae to record grains/siliqua and 1 000-grain weight. The percentage of seed germination, plumule and radicle length was recorded at room temperature (30±2°C) by rolled towel method (ISTA 1976) after 4 and 8 days. The treatments were replicated four times.

Diseased plants of all the varieties, the growth and yield parameters were significantly reduced barring height that too in one variety 'RH 8812'. The significant reduction in the height of diseased plants in 'RH 8812' may be attributed to drastic reduction of siliquae number in primary and secondary branches and vice versa in other two varieties (Table 1). Roy and Saikia (1976) also observed fewer pods and shrivelled seeds in affected plants. The primary branches were at par in healthy and diseased plants. As the disease appears after flowering by which time primary branches have developed, no difference could be observed in the primary

branches of healthy and diseased plants. However, reduction of 41.1, 41.5 and 31.8% was observed in secondary branches of diseased plants in 'RH 30', 'RH 8812' and 'T 59', respectively. The maximum percentage reduction of grains/siliqua in primary and secondary branches was 17.3 and 9.3 in 'RH 8812' and 'RH 30', respectively. The 1 000-grain weight reduced greatly (57.4%) in 'RH 30' which differed significantly to 'RH 8812' (29.4%) and 'T 59' (33.3%). Heavy yield losses due to white rot in Indian mustard have also been reported earlier (Roy and Saikia 1976, Gupta *et al.* 1994). Sharma and Kanwar (1989) also reported adverse effect of white rot on pod yield of peas. The seeds from diseased plants resulted in significant recession in germination percentage. The plumule and radicle length of germinated seeds was considerably reduced at both the intervals. The similar reductions due to alternaria blight in brown sarson has been recorded by Sharma *et al.* (1994).

SUMMARY

An investigation carried out at Bawal during 1995-96 and 1996-97 on white rot disease of mustard caused by *Sclerotinia sclerotiorum* showed that it has an adverse effect on the growth and yield contributing parameters. Significant reduction in height; secondary branches; siliquae/primary and secondary branches; germination percentage; radicle and plumule length was recorded in diseased plants against healthy plants. However, no statistical difference existed among diseased and healthy plants with regards to primary branches, grains/siliqua in primary and secondary branches.

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*Short note

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Table 1 Losses estimation due to white rot in Indian mustard varieties under natural conditions*

Character	Plant type	Varieties			Per cent reduction		
		'RH 30'	'RH 8812'	'T 59'	'RH 30'	'RH 8812'	'T 59'
Plant height (cm)	H	185	207	205	-6.6	15.9	-2.4
	D	197.2	174	210			
CD ($P=0.05$)			18.71				
Primary branches (No.)	H	5.4	5.5	5.5	0.0	0.0	0.0
	D	5.4	5.5	5.5			
Secondary branches (No.)	H	29.6	20.5	17.6	41.1	41.5	31.8
	D	17.4	12.0	12.0			
CD ($P=0.05$)			9.79				
Siliquae/primary branches (No.)	H	225.6	217.5	154.6	5.8	41.4	4.5
	D	212.4	127.5	147.6			
CD ($P=0.05$)			37.51				
Siliquae/secondary branches (No.)	H	506.0	308.5	240.6	43.6	63.0	1.7
	D	285.2	114.0	236.6			
CD ($P=0.05$)			123.8				
Grains/siliqua in primary branches	H	14.1	15.0	13.9	7.8	17.3	4.3
	D	13.0	12.4	13.3			
Grains/siliqua in secondary branches	H	15.1	15.9	15.7	9.3	5.7	5.1
	D	13.7	15.0	14.9			
1 000-grain weight (g)	H	6.1	5.1	5.7	57.4	29.4	33.3
	D	2.6	3.6	3.8			
CD ($P=0.05$)			0.296				
Germination (%)	H	87.0	80.0	80.0	85.0	88.7	60.6
	D	13.0	9.0	31.5			
CD ($P=0.05$)			3.72				
Radicle length (cm) after 4 days	H	2.8	3.1	2.4	78.9	78.4	12.5
	D	0.5 ⁹	0.67	2.1			
CD ($P=0.05$)			0.447				
Radicle length (cm) after 8 days	H	5.2	7.7	7.5	26.9	18.2	48.0
	D	3.8	6.3	3.9			
CD ($P=0.05$)			0.165				
Plumule length (cm) after 4 days	H	2.2	1.0	2.3	100.0	70.0	70.4
	D	0.0	0.3	0.68			
CD ($P=0.05$)			0.21				
Plumule length (cm) after 8 days	H	5.9	8.8	7.7	16.9	15.9	26.0
	D	4.9	7.4	5.7			
CD ($P=0.05$)			0.3				

H, Healthy; D, diseased

*Data are based on 15 plants of each variety and is average of two years

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Polysora rust of maize caused by *Puccinia polysora* and its spread in Karnataka*

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Key words: polysora rust, post entry quarantine inspection

After the implementation of New Policy on Seed Development (NPSD) in October 1988, more hybrids were introduced thus increasing the risks of introducing exotic pests and pathogens. Since Karnataka has a sizeable area under seed production programmes of both public and private sector companies, disease occurrence and incidence assumes greater significance than in places where only commercial maize production is prevalent.

Polysora rust (also known as American or Southern rust) of maize, caused by *Puccinia polysora* was first suspected to be present in India (West Bengal and Sikkim) by Payak and Renfro (1967). However, presence of *P. polysora* could not be confirmed till Payak (1994) reported its occurrence for the first time in India in 1991 from Tibetan refugee colonies in Mysore district of Karnataka.

The "American rust" was unknown in the Old World until its appearance in 1949 in Sierra Leone, where it was much more virulent than in the region of its origin. In 1950 and 1951 it caused such severe damage in several West African countries that famine threatened the indigenous population, for whom maize constituted the main food crop. The rust spread "like a brush fire" throughout the Equatorial Africa and in 1953 it appeared in the Islands of Madagascar, Reunion and Mauritius in the Indian Ocean (Orlan 1954). The origin of *Puccinia polysora* Underw. in West Africa is unknown. It may have been introduced with importation of maize from the Americas from time to time, as seed or for food (Rhind *et al.* 1952).

In October 1999, during Post-Entry Quarantine Inspection (PEQI) of maize crop raised from pesticide treated seeds at Bangalore (314 samples received from Thailand, in two consignments), moderate to severe infection of rust was noticed. The infected samples on further examination in the laboratory revealed the uredinio spores of *Puccinia polysora* in all samples except one where teliospores were noticed. Later, large number of samples were collected from several

farms of seed companies and from farmers' fields in and around Bangalore covering around 100 km radius. On laboratory examination, it was noticed that all the collected samples had infection of *P. polysora*, except one, which was found to be infected by *Puccinia sorghi* (Common rust).

The identification of the rust in this case was based on the symptoms on the plant, spore characters and their measurements. We have noticed only the uredinial stage in all the collected samples except one, which was found to contain telial stage. Lesions containing uredinia were noticed on both the sides of the leaves and sheaths, densely scattered, circular, mostly 0.2–1.0 µm. in diameter; urediniospores were ellipsoidal, often subangular with straight and parallel sides, 28–38 x 22–30 µm, wall pale, minutely and sparsely echinulate and 1–2 µm thick. Teliospores were obovate, slightly constricted at septum and measured 35–50 x 16–26 µm. These characters match with those described by CMI (1964) for *Puccinia polysora*.

Investigations in Canada and the United States have shown that spores of cereal rusts can be carried in viable condition by air currents to more than 16,000 feet altitude and for several hundred miles from the place of origin. The rapid spread of this rust in Africa and the simultaneity of its appearance in Madagascar, Reunion, and Mauritius gives very good evidence of long-distance dissemination especially by aerial currents at high altitudes (Orlan 1954).

Losses up to 50 to 70% were reported in West Africa resulting in import of grains to meet food shortage (Wood and Lipscomb 1956). Similar losses are reported from Mauritius (Orlan 1954). Spectacular price rises were reported in Dahomey and Nigeria (Meiffren 1950; NAD 1953). An assessment on crop losses in USA revealed that grain yield reduced by 17 and 39% in Pennsylvania and Maryland, respectively (Raid *et al.* 1988). Near-isogenic lines were used to determine yield losses. Susceptible hybrids in three bi-weekly plantings (beginning c. 25 May) in 1976 and 1978 showed average yield reductions of 4, 23 and 45% (Rodriguez *et al.* 1980). Heavily infected late sown maize in Kentucky in 1974 gave yields of 5.32 tonnes per ha, compared with 9.6 tonnes per ha for non-infected early sown maize. Heavy rust infection encouraged severe lodging (Futtrell 1975). Epiphytotic of Southern rust occurred in Southern

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USA in 1972, 1973 and 1974 (Bailey *et al.* 1987).

Among the other two rusts of maize, *Puccinia sorghi* (Common rust) is known widely in India but *Physopella zaeae* (tropical rust) is not yet reported from the country. *P. sorghi* can be distinguished from *P. polysora* by its larger, usually more sparse and elongated uredinia; the regular, well rounded, darker urediniospores; the dark brown erumpent telia, and the well rounded teliospores, with thicker apical walls and long pedicels, and from *Physopella zaeae* having hyaline urediniospores and covered telia containing sessile teliospores. At molecular level *P. polysora* can easily be distinguished from *P. sorghi* by the RFLP patterns of the ITS regions (Hirayae *et al.* 1998).

A perusal of literature reveal that *Puccinia polysora* is known to occur in the Asian-Pacific region in Brunei Darussalam, Cambodia, China, Taiwan, Christmas and Coconuts Islands, India, Indonesia, Japan, Malaysia, Philippines and Vietnam; and in several parts of Africa, Western Hemisphere and Oceania (CMI 1992).

In view of the devastating nature of *Puccinia polysora*, it is suggested that all those concerned with the seed production in India should ensure that their crops are kept free of infection by this rust through field sanitation, destruction of crop residue by burning, crop rotation, use of resistant planting material with an Integrated Pest Management (IPM) strategy.

SUMMARY

In India presence of polysora rust of maize (*Zea mays* L.) (also known as American or Southern rust) caused by *Puccinia polysora* Underw. was first confirmed from Tibetan refugee colonies in Mysore district of Karnataka. In October 1999, during Post-Entry Quarantine Inspection (PEQI) of maize crop raised at Bangalore, moderate to severe infection of this rust was noticed. The *P. polysora* caused crop losses up to 50 to 70% in West Africa, resulting in import of grains to meet food shortage. It is suggested that seed producers in

India should ensure that their crops are kept free of infection.

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Effect of practice and schedule of irrigation on growth and yield of spring planted sugarcane (*Saccharum officinarum*)*

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Key words: sugarcane, practice and schedule of irrigation, cane yield, irrigation water use, irrigation water-use efficiency, water saving

Sugarcane (*Saccharum officinarum* L.) being long duration crop demands number of irrigations. At present farmers in the command of Indira Gandhi Nahar Pariyojana (IGNP) are giving 22-24 irrigations as against the recommended practice of 15 irrigations. The ways and means to reduce irrigation requirement of this crop is necessary not only to economise the water use but also to check the water table rise in canal command area. Hence, an attempt was made to study the effect of various practices and schedules of irrigation on yield and economic water-use in sugarcane.

The treatments comprised 4 practices of irrigation, viz M_1 , irrigation in flat plot; M_2 , irrigation in all furrows; M_3 , irrigation in alternate furrow and M_4 , irrigation in alternate furrow in rotation (odd/even) in main treatments and 3 schedules of irrigation, viz I_1 - IW : CPE ratio 0.6, I_2 - IW : CPE ratio 0.9 and I_3 - IW : CPE ratio 1.20 as sub-treatments. The experiment was laid out in split plot design with 3 replications.

'CO 66-17' sugarcane was planted in rows spaced 75 cm apart during first week of March and harvested during January/February in both years. The crop was fertilized with 150 kg N+ 17.6 kg P + 33.2 kg K/ha. The soil was sandy loam in texture having pH 8.2 and EC 0.20 mmhos/cm, organic carbon 0.18% and the available P 33 kg/ha and K 330 kg/ha. Average values of field capacity, permanent wilting point and bulk density were 16.2%, 6.3% and 1.53 g/cc, respectively.

Measured quantity of irrigation water was applied with the help of 15 cm. Parshall flume fixed in the irrigation channel. One pre-plant irrigation of 100 mm depth was given for better land preparation and good germination of the crop. Two common irrigations of 60 mm depth were applied for establishment of crop and preparation of ridge and furrow. Thereafter, the irrigations of 60 mm depth were scheduled as per IW : CPE ratios.

Data recorded on number of millable canes, commercial

cane sugar content, cane yield, green fodder yield, harvest index, total irrigation water use, irrigation water-use efficiency and saving in irrigation water are presented in Table 1. Observation revealed that only the cane yield was influenced significantly by practices of irrigation and irrigation schedules. Irrigation practice treatments, P_2 (62.851 tonnes/ha) and P_4 (62.080 tonnes/ha) and P_3 (49.859 tonnes/ha) and P_1 (48.372 tonnes/ha) recorded appreciable lead in the cane yield. Irrigation schedule treatments, I_3 (59.275 tonnes/ha), I_2 (58.635 tonnes/ha) and I_1 (49.462 tonnes/ha) also recorded significant difference between the treatments.

Interacting response of irrigation practice and schedule was also observed on cane yield. Cane yields of 66.672 and 66.908 and 66.374 and 66.484 tonnes/ha were obtained respectively under irrigation practice of all furrows (P_2) and irrigation in alternate furrow in rotation (P_4) along with irrigation schedule IW:CPE ratio 0.9 (14 irrigations) and IW:CPE ratio 1.2 (18 irrigations). These treatments were at par and significantly superior to the rest of the treatment combinations (Table 2).

In general irrigation practices of P_1 and P_2 recorded 1407.2 mm irrigation whereas P_3 and P_4 recorded 977.2 mm irrigation. The irrigation water use was 1042.2 mm, 1199.7 mm and 1334.7 mm in IW:CPE ratio 0.6, 0.9 and 1.2 respectively. Irrigation water use efficiency recorded was maximum in irrigation practice of P_4 (63.71 kg/ha-mm) and minimum in irrigation practice of P_1 (34.54 kg/ha-mm). There was 30.3 per cent saving in irrigation water under P_4 as compared to P_1 and P_2 . The result confirms the findings of Patel *et al.* (1989) and Ramesh (1997).

The moisture distribution pattern at different lateral and vertical distance (0-90 cm) was studied before and after each irrigation under all the four practices of irrigation. There was very little difference in the moisture content at different lateral distance under all the four practices of irrigation. This suggests that there is a possibility of contribution of moisture to the adjacent non-irrigated furrows from irrigated furrows through lateral movement of water.

Though all furrow method gave some higher cane yield,

* Short note

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Table 1 Effect of different practice and schedule of irrigation on growth, cane yield, total irrigation water use, irrigation water use efficiency and saving in irrigation water in spring planted sugarcane (average of two years)

Treatments	Number of millable canes ('000/ha)	Commercial cane sugar (%)	Cane yield (tonnes/ha)	Green fodder yield (tonnes/ha)	Harvest index (%)	Total irrigation water-use (mm)*	Irrigation water-use efficiency (kg/ha-mm)	Saving of irrigation water (mm) in P ₃ and P ₄ as compared to P ₁ and P ₂
<i>Practice of irrigations</i>								
Irrigation flat	57.6	12.06	48.372	21.345	69.38	1407.2	34.54	
Irrigation in all furrows	58.2	12.60	62.851	25.430	71.19	1407.2	44.82	
Irrigation in alternate furrow	57.8	12.13	49.859	22.220	69.17	977.2	51.23	430 (30.3%)
Irrigation in alternate furrow in rotation	60.0	12.33	62.080	25.340	71.01	977.2	63.71	430 (30.3%)
CD (<i>P</i> =0.05)	NS	NS	0.724					
<i>Irrigation schedule</i>								
IW : CPE 0.6	59.1	12.30	49.462	21.275	69.92	1042.2(11)	48.78	
IW : CPE 0.9	57.6	12.26	58.635	24.575	70.47	1199.7(14)	50.71	
IW : CPE 1.2	58.5	12.28	59.275	24.901	70.42	1334.7(18)	46.23	
CD (<i>P</i> =0.05)	NS	NS	0.765					

* Including rainfall and pre-sowing irrigation of 100 mm, Data in parentheses represent number of post-sowing irrigations in total irrigation water use

Table 2 Interaction effect of practice and schedule of irrigation on cane yield of spring planted sugarcane (tonnes/ha) average of 2 years)

Treatments	IW : CPE-0.6	IW : CPE-0.9	IW : CPE-1.2	Mean
Irrigation in flat	43.556	49.991	51.569	48.372
Irrigation all furrow	54.975	66.672	66.908	62.851
Irrigation alternate furrow	45.940	51.500	52.139	49.859
Irrigation alternate furrow in rotation	53.376	66.379	66.484	62.080
Mean	49.462	58.635	59.275	
	<i>SEm</i> ±	<i>CD</i> (<i>P</i> =0.05)		
Practice	0.2093	0.724		
Schedule	0.2553	0.765		
Practice x schedule	0.5105	1.530		

it would be advisable to adopt alternate furrow method in rotation (odd/even) not only to bring more area in the command but also to check the rise in water table in command area of Indira Gandhi Nahar Pariyojna (IGNP).

significantly superior over all other treatment combinations. Highest irrigation wateruse efficiency of 63.71 kg/ha-mm and water saving of 30.3% were recorded under irrigation practice of P₄ as compared to P₁ and P₂.

SUMMARY

A field experiment was conducted on spring planted sugarcane with practices of irrigation, viz P₁, irrigation in flat plot; P₂, irrigation in all furrows; P₃, irrigation in alternate furrow and P₄, irrigation in alternate furrow in rotation and 3 schedules of irrigation; viz I₁, IW:CPE ratio 0.6; I₂, IW : CPE ratio 0.9 and I₃, IW:CPE ratio 1.2 . The cane yields obtained under P₂ and P₄ along with I₂ and I₃ were at par and

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Evaluation of some dominant banana (*Musa paradisiaca*) growing soils of Wardha district in Maharashtra state for their suitability classification*

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Key words: banana growing soils, suitability classification, land evaluation

The cultivation of banana (*Musa paradisiaca* L.) is becoming increasingly popular in Wardha district due to better adaptability of local cultivars, availability of irrigation

water and good economic returns but it is cultivated without considering the potentiality of soils leading to differential banana yields as observed from the farmer's fields. In view of this, the present investigation was undertaken with the objectives to characterise the banana growing soils in the

*Short note

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Table 1 Climatic and soil-site requirement criteria for banana cultivation for central India*

Characteristics	Degree of limitation				
	0 (None)	1 (Slight)	2 (Moderate)	3 (Severe)	4 (Very severe)
<i>Climatic characteristics</i>					
Annual rainfall (mm)	>1 000	900-1 000	800-900	700-900	<700
Mean annual temp. (°C)	26-28	24-26	22-24	20-22	<20
Relative humidity	>60	50-60	40-50	<40	
<i>Site characteristics</i>					
Slope (%)	0-1	1-3	3-5	5-8	>8
Erosion class	e1	e1	e2	e3	e4
Drainage class	Well	Well	Mod. well/ Somewhat excessively drained	Imperfect	Poor
Flooding	F1	F1	F2	F3	F3+ (non- drainable)
Surface stoniness (%)	<3	3-15	15-40	40-75	>75
<i>Soil characteristics</i>					
Texture (surface)	CL,SCL,SICL	C,SC (non- expanding type <60% clay	LS,SIL,SL, C(expanding type <60% clay	C (expanding type, type ≥60%	S, CS
Soil depth (cm)	>125	100-125	75-100	50-75	<50
CaCO ₃ (%)	<10	10-15	15-20	20-25	>25
Coarse fragments (%)	<3	3-15	15-35	35-50	>50
<i>Soil fertility</i>					
Base saturation (%)	>75	50-75	25-50	<25	--
Organic carbon (%)	>1.0	0.50-1.0	0.25-0.50	<0.25	--
ECe (dSm-1)	0-1	1-2	2-4	4-6	>6
pH (1:2.5)	6.5-7.5	7.5-8.5	8.5-9.0	>9.0	

*Developed for irrigated banana based on available literature and local expertise

Table 2 Climate and soil-site characteristics of study area

Characteristics	Soils							
	Typic Hapl- usterts (P-1)	Typic Hapl- ustepts (P-2)	Typic Hapl- ustepts (P-3)	Fluventic Haplustepts (P-4)	Typic Haplustepts (P-5)	Typic Haplustepts (P-6)	Typic Haplustepts (P-7)	Typic Haplustepts (P-8)
<i>Climatic characteristics</i>								
Total rainfall (mm)	934	934	934	934	934	934	934	934
Mean air temp. (°C)	26	26	26	26	26	26	26	26
Relative humidity (%)	52	52	52	52	52	52	52	52
<i>Site characteristics</i>								
Slope (%)	0-1	1-3	1-3	1-3	1-3	1-3	1-3	1-3
Erosion	e1	e1	e1	e1	e1	e1	e1	e1
Drainage	Mod.well	Well	Well	Well	Well	Mod. well	Well	Well
Flooding	F0	F0	F0	F0	F0	F0	F0	F0
Surface stoniness (%)	<3	<3	<3	<3	<3	<3	<3	<3
<i>Soil characteristics</i>								
Surface texture	c	cl	sl	ls	cl	c	c	cl
Clay (%)	73.2	44.7	16.4	22.3	24.4	73.0	50.0	26.1
Depth (cm)	126	126	132	107	125	126	133	126
PAWC (mm)	207	153	143	172	155	102	174	92
CaCO ₃ (%)	2.7	14.8	14.6	13.4	15.3	13.5	11.8	14.5
Coarse fragments (v/v)	1.0	7.4	22.3	4.6	26.0	2.8	7.6	8.4
<i>Soil fertility</i>								
CEC (cmol(p+)/kg)	70.6	43.7	13.7	21.2	24.9	68.4	48.3	24.1
Organic carbon (%)	0.52	0.34	0.37	0.56	0.30	0.37	0.25	0.51
Base saturation (%)	95.3	97.2	91.7	92.8	93.9	96.8	97.2	91.9
ECe (dSm ⁻¹)	0.14	0.17	0.02	0.03	0.03	0.14	0.06	0.02
<i>Observed banana yield</i>								
(tonnes/ha)	45	75	80	92	68	50	80	110

district and to identify the soil-site attributes responsible for the differential banana productivity in order to assess the soil-site suitability for banana cultivation on sustainable basis.

The study area covering Vadgaon (P-6 and 7), Mohi (P-2, 3 and 5), Hingni (P-4) and Pawnar ((P-1) villages in Selu tehsil of Wardha district lies between 20°46' to 20°54' N latitudes and 78°40' to 78°43' E longitudes. The climate is tropical dry subhumid monsoon type with an average annual rainfall of 934 mm and the mean annual, mean maximum and mean minimum temperatures of 26°C, 32.6°C and 19.4°C, respectively. The relative humidity varies from 33 to 80 per cent. The soil moisture regime is *Ustic* and the soil temperature regime is Hyperthermic with the length of growing period (LGP) of 168 days.

Based on the observed differential growth and yield of banana in the study area, eight representative pedon sites were selected during the year 1997 and were examined for soil-morphological properties. The soil samples were collected and analysed by following the standard procedures (Jackson 1973). Soils were classified as per USDA Soil Taxonomy (USDA, Washington DC, 1998) up to family level.

Suitability of the soils for banana cultivation was assessed

based on crop requirements (described for central India) (Table 1) and soil-site characteristics (Table 2). The soil characteristics in Table 2 have been expressed on weighted mean basis. The soil-site characteristics were expressed in terms of degree of limitation (0, 1, 2, 3, 4) as per standard definition (FAO, Rome 1976). The evaluation of soil-site characteristics was done as per the criteria suggested by Sys *et al.* (1991).

The pedons are calcareous and developed over basaltic alluvium in piedmont/flood plain. The study area pose slight limitation of climate in terms of total rainfall and relative humidity, however, frequent but light irrigations (furrow/drip) overcome these constraints. To protect from wind velocity particularly in summer months, farmers generally plant castor or papaya on field bunds.

The computation level of limitations (simple limitation method) revealed that pedon-8 (Fine, smectitic, Typic Haplustepts) underlain by coarse textured (loamy sand) substratum appeared to be highly suitable (S1) having slight limitation of slope, erosion, texture, CaCO₃, coarse fragment, organic carbon and pH. Pedon-2 (Fine, smectitic, Typic Haplustepts), Pedon-3 (Coarse-loamy, mixed Typic

Haplustepts), Pedon-4 (Coarse-loamy, mixed, Fluventic Haplustepts), Pedon-5 (Fine-loamy, smectitic Typic Haplustepts) and Pedon-7 (Fine, smectitic, Typic Haplustepts) are rated as moderately suitable (S2), Pedon-2 posses moderate limitation of organic carbon while Pedon-3 had moderate limitation of texture, coarse fragment and organic carbon. The pedon-4 is associated with moderate limitation of texture, Pedon-5 with moderate limitation of CaCO_3 , coarse fragment and organic carbon while Pedon-7 posses moderate limitation of organic carbon. Banana is heavy feeder of nutrients and hence maintaining of optimum amount of organic carbon is must through FYM or other sources. It has more significance because banana (trunk) is uprooted and thrown away and its leftover (residues if any) is not easily decomposed. The Pedon 1 and 6 (Very-fine, smectitic Typic Haplusterts) have severe limitations of texture (>60% clay), moderate limitation of drainage and hence classified as marginally suitable (S3).

The land evaluation carried out by matching the soil-site characteristics of the studied soils (Table 2) with soil-site requirements of banana (Table 1) suggests that the amount of clay content and drainage of the soil are the dominant characteristics contributing towards banana yield, followed by coarse fragments, CaCO_3 , organic carbon content, pH, exchangeable Ca and Mg. The study suggested that pedon-8 is highly suitable, while pedon-2, pedon-3, pedon-4, pedon-7 are moderately suitable, whereas pedon-1 and pedon-6 are marginally suitable for banana productivity.

SUMMARY

The dominant banana growing soils in Vidarbha region

of Maharashtra were characterised and evaluated for their suitability under irrigated condition. The soils supporting banana were very deep, well drained to moderately well drained, calcareous with varying texture depending on their occurrence on different physiographic positions. These have been developed over basaltic alluvium in piedmont / flood plain (1 to 3% slope) and are slightly eroded. These soils had low organic carbon (<0.50%) and moderately alkaline in reaction.

The dominant soil-site parameters such as drainage, texture (control section), CaCO_3 and organic carbon were found to determine the suitability of particular soil unit for banana cultivation in this region. The yield observed from each land unit matched well with the suitability class determined on the basis of degree of limitations. Such suitability evaluation criteria worked well in the given agro-ecological region and hence was recommended for determining the potential area for extending of banana cultivation in Vidarbha region of Maharashtra, India.

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Saline sodic soil changes by inoculation of *Tolypothrix tenuis* (cyanobacteria) sheaths or exopolysaccharide*

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Key words: cyanobacteria, exopolysaccharide, sheaths, soil stability, *Tolypothrix tenuis*

The addition of cyanobacterial biomass increases stability of soil aggregate (Rogers and Burns 1994; Cano *et al.* 1997). The importance of cyanobacterial exopolysaccharide as a major factor of soil particles aggregation was assessed by Caire *et al.* (1997). Polysaccharide liberated by cyanobacteria may dilute in the soil solution and/or form extracellular investment or sheaths.

In this paper we compared the effect exopolysaccharide or sheaths isolated from a *Tolypothrix tenuis* culture on chemical, biological and structural properties of a saline sodic soil, mainly used as grassland and with its structure altered by the excess of sodium.

Strain *Tolypothrix tenuis* (Kutz) J. Schmidt em. was cultured in Allen and Stanier modified medium (Caire *et al.* 1997) under fluorescent light 45 $\mu\text{E}/\text{m}^2/\text{s}$. Cyanobacterial mass (stationary phase) was separated by centrifugation and 0.64 g dry weight biomass/L were obtained.

For each experiment (40, 180 and 360 days), exopolysaccharide (EPS) was isolated from the culture medium (pH 7.2) by the method of Nakagawa *et al.* (1987) and concentrated 3 fold. It was sterilized by filtration through a Millipore membrane 0.22 μm pore diameter. Sheaths were isolated from the total biomass corresponding to the above cited culture following the same method to obtain the total cell-free sheath fraction suspended in distilled sterile water.

A saline sodic soil Typic Natralboll with clay silt loam texture, total C 19.2 mg/kg, total N 2.0 mg/kg, CEC 18.4 cmolc/kg, EC 4.1 dS/m, ESP 23.2%, pH 7.4 was collected at 0-15 cm depth. Non-sterile soil samples were dried, sieved through a 2mm pore diameter sieve, and 120 g of soil were dispensed in each plastic box (13x 8x5cm). The soil was then saturated with distilled water (160 g final weight). The boxes were kept in dark, at 25 \pm 1^oC and with constant moisture contents at saturation. At 40, 180 and 360 days,

10 boxes containing the soil received 65 ml each of EPS solution; 10 received 30 ml each, of sheath suspension. The remaining 10 boxes were kept as controls.

Soluble carbon was assessed by Davidson *et al.* (1987) technique. Microbial activity was studied by arginine ammonification (Alef and Kleiner 1987). Soil aggregate stability was assessed by wet sieving (Grieve 1979). Bouyoucos technique (1962) without addition of dispersing agent, was used to evaluate the percentage of 50 μm and 2 μm aggregates. All soil samples were assayed in triplicate.

The data were subjected to a standard analysis of variance assuming a randomized complete block design. A two ways ANOVA at $P < 0.05$ was carried out for the treatments.

Addition of EPS produced significant increases of 64, 125 and 104% in soluble C, at day 40, 180 and 360, respectively (Table 1). After 360 days the soluble C difference between treatment and control (14.94 mg/kg) was smaller than at 180 days (15.14 mg/kg) because EPS addition was not repeated and also because microflora activity was high and constant from day 40 (11.64; 12.03 and 11.01 $\mu\text{g NH}_4\text{-N}/\text{kg/h}$ for days 40, 180 and 360, respectively). On the other hand, in control soil, microbial activity increased slowly with wetting, microorganisms consuming organic matter already present in the soil, thus reducing soluble C (21.06-14.36 mg/kg, from day 40 to day 360). Soluble C diminished in treated soils with time due to constant microbial activity, whose increments compared to control were 272%, 81% and 49% at day 40 (11.64 $\mu\text{g NH}_4\text{-N}/\text{kg/h}$), after 180 days (12.03 $\mu\text{g NH}_4\text{-N}/\text{kg/h}$) and after 360 days (11.01 $\mu\text{g NH}_4\text{-N}/\text{kg/h}$) respectively.

Sheaths addition produced 237.4% soluble C increase (28.75 mg/kg) after 180 days. After 360 days the increment of soluble C (29.17 mg/kg) was 178%. The average mean over time for sheaths is 14.24 mg/kg (control) and 43.20 mg/kg for treatment (more than 200% increase). The average mean over time soluble carbon values were lower in EPS treatments (15.84 and 30.39 mg/kg for control and EPS treated samples, respectively. (Table 1) as compared to sheaths. Unlike EPS treatment, microbial activity after sheath addition, constantly increased till the end of the

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Table 1 Effect of *Tolypothrix tenuis* EPS on soluble C and microbial activity of soil

Time (d)	Soluble carbon (mg/kg+)		Microbial activity ($\mu\text{g NH}_4\text{-N/kg/h+}$)	
	Control	Treated	Control	Treated
40	21.06 d	34.62 a	3.12 c	11.64 a
180	12.11 ef	27.25 bc	6.66 b	12.03 a
360	14.36 ef	29.30 bc	7.37 a	11.01 a

Values represent mean (n=6). Different letters show significant statistical difference between treatment for each variable ($p < 0.05$)

experiment, though increments decreased with time (294% at day 180 and 228% at day 360) probably as a consequence of increasing microbial activity of the control (due to wetting and organic matter of the untreated soil). At day 180, sheaths addition increased soluble C (237%) and microbial activity (300%) significantly more than the addition of EPS (125 and 84%, respectively).

Weight percentage of aggregate smaller than 2 μm decreased with time for both treatment as compared with control (ie 85 and 98.4% for EPS and sheaths, respectively, at day 360). For EPS and sheaths addition and after every time period the weight percentage of aggregates with sizes ranging between 2 and $>2000 \mu\text{m}$ increased compared to control, except for aggregates in the size range 2-50 μm , which registered increase at day 360. The weight percentage of aggregates of 250 - 500 μm remained almost the same throughout the experiment. With EPS, aggregates bigger than 2000 μm increased 11.21 fold compared to control at day 180 and in the range 500 - 1000 μm : 14.2 fold at day 360. For 360 days, aggregates bigger than 2000 μm were not tested, Sheaths addition produced the highest increase of weight percentage of aggregates compared to control in the range 1000-2000 μm : 18.57 fold at day 180 and in aggregate bigger than 2000 μm : 18.08 fold at day 360,

The size of aggregate showing highest increments increased with time for both treatments, EPS or sheaths, probably because of the fact that, as microbial activity increased, microorganisms produced additional organic matter (light carbon) that cemented soil particles forming larger aggregates. Aggregates size also increased with both treatments, but sheaths produced larger aggregates than EPS at the same period of time.

SUMMARY

Exopolysaccharide (EPS) and sheaths isolated from a *Tolypothrix tenuis* were inoculated in a saline soil, in a greenhouse experiment. EPS increased soluble C by 64%, 125% and 104% and microbial activity by 273%, 81% and 49%, at 40, 180 and 360 days after soil inoculation, respectively. Sheath addition also increased soluble C by 237% and 178% and microbial activity by 294% and 228% at 180 and 360 days, respectively. The size of aggregates stable to water increased with time for both treatments. EPS produced the highest increase in aggregates $>2000 \mu\text{m}$ (11.21 fold) at day 180 and aggregates between 500 and 1000 μm (14.22 fold) at day 360. With sheaths, the highest increase was for aggregates between 1000 and 2000 μm (18.57 fold) at day 180 and $>2000 \mu\text{m}$ (18.08 fold) at day 360. Sheaths produced higher increases than EPS in the largest aggregates in part as a consequence of a higher increase of microbial activity.

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Comparing several crop husbandry practices with soil solarization for weed control and crop yield in soybean (*Glycine max*) - broccoli (*Brassica oleracea* convar *botrytis* var *italica*) cropping system*

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Key words: broccoli, cowpea, irrigation, solarization, soybean, tillage, weed and wheat

Soil solarization during the hot summer months (May and June) is established useful and practicable for controlling weeds in *kharif* as well as in the succeeding *rabi* season (Biradar *et al.* 1997; Yaduraju *et al.* 1999). Also there are several age-old and time-honoured crop husbandry practices (Das and Yaduraju 1999) which affect the growing environment of the crop and weeds and selectively favour the germination, growth and establishment of one plant or a group of plants. There thus occurs a continuous dynamics of the flora in a crop-weed ecosystem, which results in varying order of competition between crop and weeds. And it is the competition whose exploitation many a time appears to be a possible weed control strategy. The present experiment was, therefore, undertaken for an overall comparison of the weed control efficacy of several crop husbandry practices including soil solarization in soybean (*Glycine max* L.) - broccoli [*Brassica oleracea* L. convar *botrytis* (L.) Alef. var *italica* Plenck] cropping system.

A field experiment laid out in a split plot design with six crop husbandry practices, viz control, repeated tillage with and without irrigation, soil solarization, cowpea cropping and wheat straw incorporation in main plots and unweeded control and weed free check in sub-plots was undertaken at the Institute, New Delhi during the *kharif* and *rabi* seasons of 1997 and 1997-98, respectively. The soil was sandy loam, medium in fertility and alkaline in reaction. All the treatments were deployed in the field during the hot summer months starting from first/second fortnight of May and continued up to the end of June. On an average, four tillage operations at a certain interval followed by irrigation were given in the repeated tillage with irrigation treatment, whereas irrigation was withheld but similar tillage level maintained in the repeated tillage without irrigation treatment. Polyethene film (100 μ thickness) was used in the soil solarization plots and was installed in the field in the second fortnight of May. For

cowpea [*Vigna unguiculata* (L.) Walp.] cropping treatment, cowpea was sown at the first week of May and was harvested as fodder before sowing of soybean. Wheat (*Triticum aestivum* L. emend. Fiori & Paol) straw @ 6.0 tonnes/ha was incorporated at the second fortnight of May in the wheat straw incorporation treatment. For weed free check treatment, metribuzin @ 0.5 kg/ha was used as pre-emergence followed by post-emergence application of the mixture of lactofen (90 g/ha) + fenoxaprop-p-ethyl (120 g/ha) at 20 days after sowing of soybean. Besides weeds those survived/escaped were pulled-out manually. No fresh/new treatment was deployed in the *rabi* season (1997-98). Instead the same treatments employed in the summer season were compared for their residual/carry-over effect on weed growth and consequently on crop yield maintaining the fixed lay-out. The package of practices as recommended was followed for raising soybean and broccoli.

Annual grass weed population got significantly reduced in cowpea cropping than in wheat straw incorporation and control (Table 1). Broad-leaved weed population, on the contrary, was significantly lower in soil solarization than in any other treatments except cowpea cropping. Sedge (only *Cyperus rotundus*) population was significantly lower in wheat straw incorporation than in rest of the treatments except repeated tillage with irrigation. The total weed population was, however, significantly lower in cowpea cropping treatment than in others except soil solarization and repeated tillage with irrigation. Repeated tillage with irrigation recorded significantly lower dry weight of annual grass weeds than control. Soil solarization, on the contrary, registered significantly lower dry weight of broad-leaved weeds than in others except cowpea cropping and wheat straw incorporation. Again soil solarization recorded significantly lower dry weight of sedge than control and cowpea cropping. Cowpea cropping recorded the highest sedge dry biomass accumulation mainly because of *Cynodon dactylon* dry weight, which was added up for dry weight accumulation of sedge in every treatment replication-wise. And cowpea cropping had the maximum *Cynodon* infestation observed

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Table 1 Population and dry biomass of grass, broad-leaved, sedge as well as total weeds at 40 days after sowing (DAS) of soybean in the rainy season 1997

Treatment	Population (number/m ²)				Dry biomass (g/m ²)			
	Grass	BLW	Sedge*	Total	Grass	BLW	Sedge*	Total
<i>Crop husbandry practices</i>								
Control	114	54	44	212	71.1	72.4	58.2	201.7
Repeated tillage without irrigation	82	56	44	182	44.3	73.2	24.7	142.2
Repeated tillage with irrigation	58	38	34	130	22.7	70.8	28.7	122.2
Soil solarization	52	14	60	126	23.8	11.6	23.2	58.6
Cowpea cropping	38	18	60	116	29.6	16.1	79.9	125.6
Wheat straw incorporation	98	46	20	164	52.3	42.3	25.0	119.6
LSD ($P=0.05$)	52.2	19.7	15.7	47.3	33.5	32.3	33.8	30.9

BLW, Broad-leaved weeds. *Only *Cyperus rotundus* was taken into consideration for the sedge population. However, *Cyperus rotundus* and *Cynodon dactylon* both being perennial in nature, were considered for sedges' dry biomass accumulation here, although *Cynodon* is not a sedge. *Cynodon* population could not be counted for its spreading/ trailing habit

visually. Otherwise cowpea cropping resulted in drastic reduction in growth of annual grass and broad-leaved weeds. The total weed dry weight was, however, significantly lower in soil solarization than in rest of the treatments (Yaduraju and Ahuja 1995). All other treatments, viz wheat straw incorporation, cowpea cropping, repeated tillage with and without irrigation being at par with each other recorded intermediate but significantly lower total weed dry weight than control.

The fresh weight of soybean plant increased significantly in soil solarization and in repeated tillage with and without irrigation than in others (Table 2). Soil solarization again recorded significantly greater plant height of soybean than in any other treatment except control. With regard to soybean pod/plant, wheat straw incorporation recorded the highest value which was significantly higher than in all other treatments. Cowpea cropping, repeated tillage with irrigation and soil solarization were, however, intermediary. They too registered a significant increase in soybean pod/plant over repeated tillage without irrigation and control. Again wheat straw incorporation recorded significantly higher grain yield of soybean than in others except repeated tillage with irrigation, soil solarization and cowpea cropping. Soybean's stover yield, on the contrary, was significantly higher in soil solarization than in others. This was mainly because of prolonged and vigorous vegetative growth of soybean plants in this treatment, the soybean plants, however, could not transform it fully into grains. Otherwise the soil solarization would have been the most superior. It, however, remained at par with the highest grain yield obtained in wheat straw incorporation. Weed free check recorded significantly higher values of soybean's fresh weight per plant, height, pod/plant, grain and stover yield than in unweeded control. This amply suggests that imposition of weed control measure along with

the crop husbandry practices (employed as main plot treatments) may assume a better proposition than applying them alone/singly.

In the *rabi* season (1997-98), the total (grass+broad-leaved) weed population was significantly reduced in repeated tillage with irrigation than in others except soil solarization and wheat straw incorporation (Table 2). The total weed dry weight although did not differ significantly between the treatments, wheat straw incorporation recorded the lowest value. The total broccoli curd number was significantly higher in repeated tillage with irrigation than in repeated tillage without irrigation and control. All other treatments, namely soil solarization, cowpea cropping and wheat straw incorporation, were, however, at par with it. Broccoli curd yield, on the contrary, was significantly higher in soil solarization than in rest of the treatments. The repeated tillage with irrigation, wheat straw incorporation and cowpea cropping, however, remained at par with each other and recorded intermediate values. They too produced significantly higher broccoli yield than repeated tillage without irrigation and control. Weed free check recorded significantly higher broccoli curd number and yield than unweeded control.

It may, therefore, be concluded that soil solarization although proved most promising, the crop husbandry practices like wheat straw incorporation, repeated tillage with irrigation and cowpea cropping could also hold a promise in terms of production of higher crop yield of soybean and broccoli through concurrent reduction in weed growth.

SUMMARY

The total weed (grass+broad-leaved+sedge) dry weight was significantly lower in soil solarization than in any other

Table 2 Soybean's fresh weight, plant height, pod number, grain and stover yield in the *kharif* season 1997 and population and dry weight of total weeds at harvest and broccoli curd number (number in '000/ha) and curd yield in the *rabi* season 1997-98

Treatment	Rainy season					Winter season			
	Soybean					Total weed		Broccoli	
	Fresh weight (g/plant)	Height (cm)	Pod (No./plant)	Grain (kg/ha)	Stover (kg/ha)	Population (No./m ²)	Dry weight (g/m ²)	Curd number ('000/ha)	Curd yield (kg/ha)
<i>Crop husbandry practices</i>									
Control	19.0	62.1	29.2	1 761	4 837	150	179.4	83.6	3 912
Repeated tillage without irrigation	23.5	61.5	34.2	1 844	3 838	130	158.4	108.5	5 705
Repeated tillage with irrigation	22.0	59.5	45.5	2 173	4 758	94	145.5	160.0	6 833
Soil solarization	23.0	65.6	43.2	2 060	6 036	110	130.8	145.2	7 652
Cowpea cropping	18.7	51.9	45.8	1 861	3 155	120	220.0	131.8	6 636
Wheat straw incorporation	17.8	59.2	49.4	2 248	3 680	114	121.3	128.8	6 667
LSD ($P=0.05$)	1.9	3.9	2.1	400	827	24.8	NS	31.8	699
<i>Weed control treatments</i>									
Unweeded control	18.3	62.8	38.7	1 655	4 060			97.4	5 346
Weed free check	23.1	7.2	43.7	2 327	4 708			155.2	7 122
LSD ($P=0.05$)	1.1	2.2	1.2	231	316			22.7	277

Soybean's fresh weight was taken at 60 DAS, whereas height at 90 DAS. Broccoli curd number and yield presented here are the sum total of three cuttings/pickings done all through the growing season

treatment in the *kharif* (wet) season 1997. Wheat straw incorporation, cowpea cropping, repeated tillage with and without irrigation too recorded significantly lower total weed dry weight than control. Wheat straw incorporation, on the contrary, recorded significantly higher soybean's pod/plant and grain yield than in others except cowpea cropping, repeated tillage with irrigation and soil solarization. The total weed population as observed at harvest in the *rabi* season, 1997-98, was significantly reduced in repeated tillage with irrigation than in others except soil solarization and wheat straw incorporation. Broccoli curd yield was significantly higher in soil solarization than in rest of the treatments. Repeated tillage with irrigation, wheat straw incorporation and cowpea cropping also produced significantly higher broccoli yield than repeated tillage without irrigation and control.

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Effect of electro-mechanical colour sorting on seed quality in pigeonpea (*Cajanus cajan*) cultivar 'Pusa 33'*

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Pulse crops have been reported susceptible to weather damage (Lawan and Russel 1978) and this provides a major constraint in the availability of quality seeds of pulses. The most obvious symptoms of weather damage (rainwater wetting and field drying during the crop growth) are visual changes in seed coat of weathered seeds (William *et al.* 1995). These symptoms include fading/discoloration, wrinkling, cracking and/ or sprouting of seed. The visual symptoms of weather damage are associated with underlying physiological changes to a seed and its seed coat, which in turn reduce the seed quality (germination value, vigour and storability). Fading and discoloration may be classified as primary weather damage and further deterioration as secondary damage. The conventional post harvest processing methods, ie winnowing, screen grading and specific gravity separation removes the secondary weather damaged seeds. However, the discoloured seed, which represent primary weather damage could not be removed and require special technique to get separated from the seed lot.

The present study was conducted to analyze the performance of seed separation process by hand picking (manual sorting) and machine sorting on colour basis. Such separated seeds have been assessed for quality parameters like germination percent, vigour index, electrical conductivity, particle density and test weight, to examine quality of separation. Performance indices for colour separation process were evaluated to examine the degree of separation.

Experimental technique

The experimental material was breeder seed of pigeonpea (*Cajanus cajan*) 'Pusa 33' of kharif 1998. After conventional seed processing, seed germination percent was found much below the minimum seed certification standards. The processed seed lot contained significant amount of discoloured seed. Hence, in order to separate the undesirable discoloured seed from the lot, manual sorting and electro-

mechanical colour sorting methods were adopted. The electronic colour sorting machine (*Make- Anazi Mfg. Co. Japan, Model - Alsomac BTC - 02*) is comprised feeder, background filters, ejectors, photoelectric sensors, light source and a microprocessor. The sensors scan the seed individually and compare its colour with the colour of pre-selected background filter. If the colour of seed coat does not match with the colour of background filter, a signal through the microprocessor activates the ejectors to deflect the seed into reject port. Conversely, when the colour of seed coat match properly with color of background filter (desired colour), seed follows its normal path and collected in product port.

At steady state of operation, 500 g samples were drawn from product stream and reject stream. The samples were analysed for colour purity. The material collected in product and reject ports was weighed to reckon the recovery and rejection.

A team of workers was deployed for manual sorting. Each worker was instructed to sort the desired coloured seed by comparing it with a reference colour card. The samples of feed, product and reject of both manual and machine sorting were subjected to seed quality analysis as per ISTA rules (ISTA 1993). The sampling was done in six replications. The germination per cent, number of abnormal seedlings and dead seeds was recorded. Ten normal seedlings of each replication were drawn at random and were subjected to reckon vigour index (VI) on dry weight basis. The electrical conductivity (EC) of seed leachates, true density (TD), test weight (TW) of 1000 seeds was also measured. In case of machine sorting, the material collected in product port and reject port were subjected to multi-pass to recover maximum number of good seeds from the seed lot. In addition, an exercise was done to find out the performance of colour sorter at different levels of colour purity.

Analytical technique

Good coloured seed was designated as "Product" and discoloured seed as "Reject". In ideal situation, all the good seed should go in product stream and all the discoloured seed in reject stream. Performance indices Ep, J, I were

*Short note

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Table I Effect of hand sorting and machine sorting on quality parameters of pigeonpea cultivar 'Pusa 33'

Process	Level	CP (%)	MC (%)	TW (g)	TD (g/cc)	EC ($\mu\text{s/cm/g}$)	GP (%)	VI	
Hand Sorting	Feed	83.50 ± 0.70	10.80 ± 0.01	8.81 ± 0.21	1.10 ± 0.004	1.66 ± 0.003	70.00 ± 1.38	22.75 ± 0.021	
	Accept	100.00 ± 0.00	10.40 ± 0.01	9.89 ± 0.15	1.25 ± 0.002	0.61 ± 0.001	89.00 ± 0.58	31.15 ± 0.11	
	Reject	0.00 ± 0.00	12.20 ± 0.01	8.95 ± 0.16	1.00 ± 0.003	2.25 ± 0.001	8.00 ± 0.49	1.60 ± 0.01	
Machine sorting	First pass (Feed)	Feed	83.50 ± 0.70	10.80 ± 0.01	8.81 ± 0.21		1.66 ± 0.003	70.00 ± 1.38	22.75 ± 0.21
		Accept	89.00 ± 0.58	10.60 ± 0.01	9.55 ± 0.17	1.16 ± 0.003	1.13 ± 0.002	81.00 ± 0.85	25.11 ± 0.16
		Reject	28.00 ± 0.69	12.30 ± 0.15	9.16 ± 0.19	1.04 ± 0.004	2.02 ± 0.003	26.00 ± 0.95	7.15 ± 0.19
	Second pass (Accept)	Feed	89.00 ± 0.58	10.60 ± 0.01	9.55 ± 0.17	1.16 ± 0.003	1.13 ± 0.002	81.00 ± 0.85	25.11 ± 0.16
		Accept	92.50 ± 0.62	10.60 ± 0.02	9.25 ± 0.17	1.19 ± 0.002	0.87 ± 0.002	87.00 ± 0.91	28.71 ± 0.17
		Reject	40.00 ± 0.70	12.40 ± 0.03	9.32 ± 0.18	1.06 ± 0.005	1.89 ± 0.006	35.00 ± 1.20	8.40 ± 0.18
	Third Pass (Feed)	Feed	28.00 ± 0.69	12.30 ± 0.15	9.16 ± 0.19	1.04 ± 0.004	2.02 ± 0.003	26.00 ± 0.95	7.15 ± 0.19
		Accept	42.00 ± 0.75	12.60 ± 0.17	9.35 ± 0.22	1.06 ± 0.005	1.87 ± 0.004	39.00 ± 1.23	9.95 ± 0.26
		Reject	10.50 ± 1.45	14.10 ± 0.23	8.65 ± 0.46	0.98 ± 0.012	2.40 ± 0.007	10.00 ± 1.48	1.25 ± 0.39
Fourth Pass (Reject)	Feed	40.00 ± 0.70	12.40 ± 0.03	9.32 ± 0.18	1.06 ± 0.005	1.89 ± 0.006	35.00 ± 1.20	8.40 ± 0.18	
	Accept	60.00 ± 0.42	12.80 ± 0.01	8.92 ± 0.02	1.07 ± 0.004	1.84 ± 0.004	53.00 ± 0.85	14.84 ± 0.13	
	Reject	11.00 ± 0.89	13.70 ± 0.08	8.92 ± 0.23	1.04 ± 0.01	2.34 ± 0.013	9.00 ± 1.85	2.43 ± 0.26	

CP, Colour purity; MC, moisture content; EC, electrical conductivity; GP; TW, test weight; TD, true density; VI, vigour index

computed as reported by Sinha and Modi (2000).

Effect of colour sorting on seed quality

The seed quality factors measured for good coloured seed (product) and discoloured seed (reject) exhibited significant differences in the both methods of separation i.e manual and machine sorting. In manual sorting the colour purity (CP) of weathered seed lot increased from 83.5% to 100% which in turn raised the germination level from 70% to 89%. Other quality parameter, viz true density (TD) and vigour index (VI) increased from 1.10 to 1.25 g/cc and from 22.75 to 31.15 respectively (Table 1). However, the quality parameter electrical conductivity (EC) decreased from 1.66 to 0.61 $\mu\text{s/cm/g}$.

On other hand, machine sorting enhanced the CP from 83.5 to 89 % in first pass. The CP of the product was further increased to 92.5% in second pass. The other quality factors also improved accordingly i.e germination level (70 to 87%), TD (1.10 to 1.19 g/cc), EC (1.66 to 0.87 $\mu\text{s/cm/g}$), VI (22.75

to 28.71) improved significantly after second pass (product portion). Third and fourth passes (reject portion) showed that the CP of accept could be increased further, but at the cost of good seeds in reject outlet (Table 1). Hence, the multi-pass colour sorting process should be restricted to two passes only so as to keep a balance in the quality improvement and loss of good seeds in the reject outlet. It has been observed that when CP is lower the EC is higher and GP is lower. This indicates that colour purity of seed is positively correlated to germination capacity and negatively correlated to EC. Hence, the EC and CP may be used as an assay of level of weather damage, which has been also reported by Williams *et al.* 1995 and Manguire 1977. It is very important to note that as CP is 100% the corresponding GP does not reach to 100%, perhaps due to transient phase of deterioration. Higher MC is also associated with lower CP, which indicates about seed coat damage and is conformed by the corresponding higher value of EC.

The performance indices were found closely linked with

the colour purity of feed. At the lower and higher level feed colour purity; the product contamination or loss (J) was found higher, whereas the separation index (I) was lower. The separation index (I) was found maximum for the seed lot which was having feed colour purity around 70%. Hence, it can be inferred that the machine colour separation could be effective for the lot which having colour purity around 70%. Alternatively, if colour purity of seed lot is low, then we have to go for multi pass colour separation at the cost of seed loss. The trend of performance indices was found similar for colour purity as well as germination. But the values were lower for germination than colour purity. It indicates that the germination capacity is directly proportional to colour purity.

The capacity of machine was found 9 kg/h which was lower (16 kg/h) than mungbean colour sorting (Sinha and Modi 2000). It may be due to sphericity of seed, which influence the flow pattern. In manual sorting, the cost of operation was found significantly higher (RS 3.5/ kg) than machine sorting (RS 1.25 / kg) and the product quality was not consistent within the group of workers. The machine sorting can successfully used to handle large quantity of seed and completing the job in time. Above all, it is very important to multiply each class (Nucleus, Breeder and Certified) of seed every year. In this chain, discontinuation of any segment will affect the availability of foundation seed in multiple years. Therefore, if seed crop is affected by adverse weather, it should be sorted by an economical viable method. In this regard, machine sorting was found suitable especially for low volume high value seeds.

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SUMMARY

Pigeonpea [*Cajanus cajan* (L.) Millsp.] cv. 'Pusa 33' was processed on colour sorting machine to remove unwanted discoloured seed and recover maximum desired coloured (good) seed. Manual separation and electronic colour sorter were analysed. In case of machine sorting, colour separation was done on a multi-pass basis to get the desired degree of seed quality. The machine performance was analysed at various colour purity levels. The desired quality parameters, eg colour purity, germination (%), vigour index, and true density improved significantly. However, undesired quality parameter, eg electrical conductivity, reduced significantly. Colour separation process was found effective at the colour purity level of around 70%. The machine sorting proved superior to hand sorting in terms of efficiency, consistency of quality of product and timeliness in operation.

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Effect of root age on bolting, seed yield and quality of Asiatic carrot (*Daucus carota*)*

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Key words: root age, bolting, seed yield, Asiatic carrot, *Daucus carota*

The commercial seed production of Asiatic carrot (*Daucus carota* L.) is undertaken in the plains by following *root-to-seed* method. *True-to-type* roots are selected for transplanting and the effect of root size and steckling density on seed production have been reported by Singh and Malik 1986, Verma *et al.* 1993 and Singh *et al.* 1994.

Even though, the size of the roots are indirectly related to their age, there is no report on the role of root age per se on the seed yield and quality of Asiatic carrot seeds. Therefore, an experiment was conducted for two crop seasons to study the effect of root age on the bolting behaviour and subsequent seed production of carrot variety 'Pusa Kesar'.

The experiment was conducted at Karnal during winter seasons of 1997-98 and 1998-99 using carrot variety 'Pusa Kesar' which belongs to Asiatic group. Seeds were sown from September to October in a staggered manner to get roots of over aged T₁ (105 days), normal T₂ (90 days) and under aged T₃ (75 days) for transplanting in the first week of January. Stecklings were selected with 15 cm length and 40-60g weight for transplanting for all the age types. They were planted in plots of 3 × 2.4 m size in a randomized block design with five replications. Each plot contained 40 stecklings with row to row distance of 60 cm and plant to plant distance of 30 cm.

Periodic observation on per cent bolting was recorded. At harvest maturity, number of secondary and tertiary branches per plant, seed yield and test weight was recorded. Germination % was obtained following ISTA (1985) procedure. One hundred seeds were placed between paper towels and kept at 22°C in a germinator for 14 days. After recording per cent normal seedlings, root and shoot lengths of 10 randomly selected seedlings were measured. Seedling vigour was calculated according to Abdul Baki and Anderson (1973).

Statistical analysis of variance for pooled data was carried out (Panse and Sukhatme 1967). Daily maximum and minimum temperatures were recorded from a nearby observatory. The cumulative degree days from seed sowing to transplanting and from transplanting to completion of

bolting was calculated following the method of Nuttonson (1955).

Effect of root age on bolting

The age of the three categories of roots used in the study are converted into their respective heat units (growing degree days) and are given along with age in calendar days in Table 1. Bolting % and accumulated growing degree days with respect to days after transplantation show similar trend in both years. All the type of roots followed a typical pattern with a slow increase in the beginning, a sharp increase in the middle and with small increase at the end. From T₁ to T₃, the root age as calculated from seeding to transplanting and their corresponding growing degree days decreased in the carrot.

However, the trend was reversed in days (accumulated heat units) to bolting initiation and to 50% bolting. In over matured roots (T₁), it required less heat units to enter the reproductive phase as it had acquired more heat degree days before transplanting. In immature root (T₃), it has to acquire the critical minimum heat units after transplanting to enter the next phenophase.

It appears that in Asiatic carrot a minimum of 2000 heat units are to be accumulated between seed sowing and 50% bolting. Requirement of heat units in case of immature root type T₃ was not attained during seed sowing to transplanting phase. Therefore, it took longer time to bolt and to attain the minimum heat units for entering into reproductive phase of the carrot.

Effect of root age on seed yield and quality

Among the different traits of yield, root age had significant effect on the total seed yield and its quality characters but no effect on number of secondary and tertiary umbels / plant or seed yield of primary umbel (Table 1). Medium aged root (T₂) showed superior performance in terms of seed yield and quality.

However, T₁ followed close behind with values statistically at par with T₂ in most of the cases. T₃ root type produced significantly less seed yield of poor test weight. Germination (%) in T₃ type was more than the standard for seed certification (60%) but was much lower than that of T₁ and

*Short note

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Table 1 Effect of root age on different characters in 'Pusa Kesar' carrot (pooled data of 2 years)

Root type	Age of root		Transplanting		Number of		Seed yield/			Seed yield 1 000 seed weight (tonnes/ha) (g)	Germination (%)	Vigour Index I	Vigour Index II	
	Days	GDD	Days	GDD	Secun-dary	Tertiary	Pri-mary	Secun-dary	Tert-iary					
Over aged	105	1821	41.5	598	9.25	13.84	7.01	11.46	4.24	1.264	2.552	85.7	1 027	1.281
Medium aged	90	1432	48.5	751	8.94	14.09	7.76	13.19	3.40	1.356	2.574	89.3	1 076	1.218
Under aged	75	1196	56.0	854	8.05	12.12	4.40	6.50	1.94	0.784	2.176	75.3	769	0.809
CD (P= 0.05)				NS		NS	1.212	1.692	0.426	0.1926	0.110	1.98	65.2	0.161

Vigour Index I = % germination × seedling length;

Vigour Index II = % germination × seedling dry weight

GDD, Growing degree days

T₂ root types. Similarly, the vigour indices were also significantly lower in seeds from T₃ (under aged). In a study carried out in Henan province of China, the carrot yields were better when adult roots and mid-adult roots were planted (Zhang *et al.* 1997).

In a temperate carrot variety 'Pusa Yamadagni', Verma *et al.* (1993) have reported that the seed yield was higher when steckling from larger roots were planted as compared to smaller roots. The greater initial vegetative growth has been attributed for the higher yield. Similar observations were made in Nantes type of carrot variety 'Red Cored Chantenay' (Eid and Abo-Sedera 1992). Therefore, the lower yields obtained from immature roots may partly be due to its smaller size of stecklings as compared to over aged and medium aged roots.

The bolting curve in T₃ showed that it took longer duration to complete 50% bolting in comparison to T₁ and T₂, having no significant difference in their maturity time. T₃ had shorter seed development period which might have resulted in less seed yield and of immature seeds. Also, due to late bolting, it was exposed to high temperatures during pollination and seed development. Elaballa and Cantliffe (1996) have reported that high temperature during pollination, fertilization and early seed development can greatly reduce carrot seed yield and quality.

The study clearly showed the influence of root age on the bolting characters, seed yield and quality of Asiatic carrot 'Pusa Kesar'. The medium aged roots (~90 days) were the best suited for transplantation of seed crop followed by over aged roots (~105 days).

Physiologically immature roots (~75 days) were not suitable for transplantation as they produced significantly lower seed yield. Although the germination of these seeds was above minimum standard for seed certification, vigour parameters were lower than the seeds obtained from other 2 root types.

SUMMARY

† A field experiment was conducted during the crop seasons

of 1997-98 and 1998-99 to find out the effect of root age on bolting characteristics and subsequent seed yield and quality of Asiatic carrot (*Daucus carota* L.) variety 'Pusa Kesar'. With decrease in age of roots, there was an increase in days to bolting initiation and 50% bolting. Irrespective of root age, bolting (%) followed a sigmoid curve for days after transplanting. Medium aged roots (90 days) gave highest seed yield of superior quality. The over-aged roots (105 days) also did well and its yield and quality were statistically at par with medium or normal aged roots. But the under-aged roots (75 days) resulted in significantly lower seed yield of poor quality. This was attributed to the delay in bolting initiation to attain the required heat units to enter reproductive phase. This subsequently reduced the duration of seed development and exposed the crop to high temperature during pollination and seed maturation.

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Effect of residue management practices and nitrogen rates on chemical properties of soil in a rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system*

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Key words: residue burning, residue incorporation, soil chemical properties, rice-wheat system

Residue management has become a problem after the adoption of combine harvesting of both rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L. emend. Fiori and Paol). Combine harvesting leaves stubble of about 30 cm in height and spread rest of the straw in the field. Straw spread on the ground is not suitable for feeding the milch cattle maintained on the farm because soil particles always get mixed into it during gathering. Burning of crop residue is most common practice. In addition to the loss of plant nutrients like nitrogen, phosphorus, sulphur and boron (Biederbeck *et al.* 1980), burning of residue creates health and environmental problems (Prasad and Power 1991). It also reduces microbial population (Raison 1979) and organic carbon content of soil (Rasmussen *et al.* 1980). On the other hand incorporation of crop residue is reported to increase the organic C and nutrient content of soil (Sidhu and Beri 1989) and to increase crop yields (Hooker *et al.* 1982). However, inhibition of plant growth due to immobilization of nutrients has been reported by Rao and Mikkelsen (1976). The present study was undertaken to study the effect of residue management practices and nitrogen rates on chemical properties of soil under rice-wheat cropping system.

The field experiment was conducted at New Delhi during July-June 1994-95 and 1995-96. The soil was sandy clay loam. At the start of experiment soil contained 0.55% organic carbon, 160 mg/kg soil available N, 15 mg/kg soil available P and 180 mg/kg soil available K.

The experiment was laid out in a split plot design with three replications. Main plot (57.75 m²) treatments were three residue management practices of preceding wheat, namely complete removal of residues from the plot, burning on the plot and incorporation into the soil by means of mould-board plough. Sub-plot (12.5 m²) treatments were 0, 60, 120 and 180 kg N/ha applied to rice grown from July to November. Wheat was grown as residual crop from November to April.

After the harvest of wheat crop, main plot treatments were applied. After 40-50 days the plots were flooded with water, tilled with a puddler and planked. At final puddling 20 kg P

and 30 kg K/ha as single super phosphate (SSP) and muriate of potash, respectively were applied to each plot. Two to three seedlings/hill of 25-30 days old of rice (cv. Pusa Basmati-1) were planted in the first week of July at spacing of 20 × 10 cm. Nitrogen as urea was applied in 2 equal splits, viz the first 10 days after transplanting (DAT) and second at 30 DAT. Rice was harvested in the first week of November.

After the harvest of rice the field was irrigated and in proper condition the land was disced and planked twice. A basal dose 40 kg N, 20 kg P and 30 kg K/ha as urea, SSP and muriate of potash, respectively were applied at final discing. Wheat variety HD 2329 was sown in the third week of November and harvested in second week of April.

Soil samples were drawn at the harvest of each crop, 120 days after incorporation of crop residue in case of rice harvest and 285 days in case of wheat harvest, from 0-25 cm soil depth and analysed for organic C, total N, available P and available K.

Organic carbon

Organic carbon content of the soil in the plot, in which wheat residue was either removed or burnt, remain more or less at initial level of 0.55 + 0.06% during two years of study (Table 1). Incorporation of residue significantly increased organic carbon content over removal or burning of residue by 0.03-0.05% in first year and 0.05-0.08% in second year of study, the increase in organic carbon due to residue incorporation was more after rice as compared to wheat.

Organic carbon content of soil also increased with increasing rate of N application upto 180 kg N/ha, however, differences between successive rates of N were not significant (Table 1). The increase in organic C content with increasing rate of N application was probably due to more root biomass production with higher rate of N application as reported by Gangaiah (1995).

Total nitrogen

Though the total N content of soil was higher when residue was incorporated as compared to its removal or burning during both the years, the differences between residue management practices were significant only during second

*Short note

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Table 1 Effect of residue management practices and nitrogen rates on organic C and total N content of soil under rice-wheat cropping system

Treatment	Organic C (%)				Total N (kg/ha)			
	1994-95		1995-96		1994-95		1995-96	
	After rice	After wheat	After rice	After wheat	After rice	After wheat	After rice	After wheat
<i>Residue management practices</i>								
Removed	0.58	0.60	0.58	0.61	328	327	326	329
Burnt	0.54	0.60	0.57	0.58	325	322	317	319
Incorporated	0.63	0.63	0.66	0.66	337	337	340	334
LSD (P=0.05)	0.032	0.023	0.084	0.064	NS	NS	13.1	10.6
<i>Nitrogen rates (kg N/ha)</i>								
0	0.51	0.54	0.49	0.56	321	313	308	310
60	0.56	0.58	0.55	0.60	325	321	320	320
120	0.59	0.62	0.61	0.62	331	329	328	328
180	0.61	0.63	0.65	0.64	335	338	339	336
LSD (P=0.05)	0.043	0.037	0.061	NS	14.2	22.5	16.9	19.4

Initial organic C : 0.55%; initial total N : 321 kg/ha

Table 2 Effect of residue management practices and nitrogen rates on available P and exchangeable K content of soil under rice-wheat cropping system

Treatment	Available P (kg/ha)				Exchangeable K (kg/ha)			
	1994-95		1995-96		1994-95		1995-96	
	After rice	After wheat	After rice	After wheat	After rice	After wheat	After rice	After wheat
<i>Residue management practices</i>								
Removed	30.0	28.7	31.3	28.1	371	347	338	332
Burnt	33.6	26.9	32.5	28.9	392	369	378	372
Incorporated	38.2	31.2	36.2	32.3	389	369	391	384
LSD (P=0.05)	3.76	2.13	1.59	2.56	NS	NS	20.6	19.4
<i>Nitrogen rates (kg N/ha)</i>								
0	37.4	33.8	35.9	32.3	395	382	403	395
60	35.5	31.2	34.6	31.1	390	372	385	377
120	33.2	28.9	32.9	29.8	383	357	365	359
180	32.4	26.2	32.0	28.3	378	354	352	346
LSD (P=0.05)	3.89	2.90	NS	2.38	NS	18.2	16.4	13.9

Initial available P : 30 kg/ha; initial exchangeable K : 360 kg/ha

year of study (Table 1). Such effects could be attributed to cumulative effect of residue incorporation in two years in same plot (Singh *et al.* 1981) and reduction of nitrogen loss in residue incorporated plots by forming organo-mineral complexes (Becker *et al.* 1984). The N content in the plots, in which residue was either removed or burnt remained at initial level 321 ± 8 kg N/ha, whereas in residue incorporated plots total N content increased over initial level by 13-19 kg N/ha.

The total N content of soil increased with increasing rate of nitrogen application, however the effect of N application on total N content of soil was significant only at 180 kg N/ha after wheat in second year (Table 1). It is interesting to note that in control plot, total N content went on decreasing

after each crop, whereas with 60 kg N/ha total N content started decreasing in second year. Application of 120 kg and 180 kg N/ha maintained a gain of 7-10 and 14-18 kg N/ha, respectively, over initial value of 321 kg N/ha during course of study.

Available P

Available P content of soil was more after rice than after wheat probably due to reduction of ferric phosphate to more soluble ferrous form and hydrolysis of phosphate compounds (Patrick and Mahapatra, 1968). Incorporation of residue also increased available P content significantly over residue removal and residue burning after both rice and wheat in both the years (Table 2). Patrick and Mahapatra (1968)

reported that addition of oxidizable materials promotes process of reduction and thus increases the content of available P in soil. Further, the available P content under residue burning practices deviated little (± 3.5 kg P/ha) from initial value of 30.1 kg/ha, a positive change after rice and negative change after wheat. Incorporation of residue increased available P content over initial value by 6-8 kg P/ha after rice and 1-2 kg P/ha after wheat crop. Gill and Meelu (1983) ascribed this increase in available P due to solubilization action of certain acids and displacement of phosphate by organic anions formed during decomposition of organic residues.

The increase in nitrogen rate from 0 to 180 kg N/ha resulted in a reduction of available P content of soil. Higher uptake of P by rice and wheat due to application of higher rate of nitrogen might be possible reason for lower available P content with higher rate of N application (Table 2).

Available K

Burning and incorporation of residue management practices were similar but significantly superior over removal of residue in respect of available K content of soil (Table 2). Burning of residue does not destroy its K content hence resulted in an increase in available K content over initial value by 31 kg/ha after first rice, 9 kg/ha after first wheat, 18 kg/ha after second rice and by 12 kg/ha after second wheat. The respective increases with residue incorporation were 29, 9, 31 and 24 kg/ha. Removal residue resulted in a progressive decline in available K content of soil ranging from 13 to 28 kg K/ha after first rice crop.

Increasing rate of N application resulted in a reduction of available K content of soil because of more uptake by both rice and wheat with higher rate of N application.

SUMMARY

In an experiment, when wheat (*Triticum aestivum* L. emend. Fiori & Paol.) residue was removed from field, organic C, total N, available P and available K content of soil was either decreased or remained at initial level. Burning of wheat residue *in situ* resulted in the decrease in organic C, total N and available P content but an increase in available

K content of soil. Incorporation of wheat residue resulted in an increase in organic C, total N, available P and available K content of soil and thus this practice significantly increased soil fertility over the practice of residue removal or burning.

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