PROJECT NO. F.AU/AGR (182)

MANAGEMENT OF ONION DOWNY MILDEW UNDER IPM IN THE NWFP, PAKISTAN

Final Technical Report
Covering
July 1, 1997 - June 30, 2000

Dr. Shabeer Ahmad
Principal Investigator

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DEPARTMENT OF PLANT PATHOLOGY
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This research report entitled "***Management of onion downy mildew under IPM in the NWFP, Pakistan***", is being submitted to the Pakistan Science Foundation. Islamabad under the following signatures.

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SUMMARY

The importance of downy mildew that attacks onion in the North West Frontier Province (NWFP) of Pakistan can be judged very well from its estimated loss of more than 50% to the crop. The disease affects both quality and quantity of the produce in the form of undersized, misshapen and less number of bulbs per unit area. The farmers of this province use different fungicides unscrupulously to control the disease. They are unaware of other methods of control such as cultural and biological which may reduce the disease inoculum and environmental pollution. These methods are easy to adopt and bear less expenses. In order to familiarize such methods among the farmers, this project research was designed to test different host management practices at the first place and to combine the best into an Integrated Disease Management Model (IDMM) for testing during the second phase.

Results of the first two years indicated that use of NPK fertilizer 120:90:60 kg/ha, plant population 0.5 million plants/ha, 8 irrigations/season, fungicides Ridomil @ 250 g/100 L plus Antracol/Dithane M-45 @ 200/300 g/100 L and herbicide "Roanstar" @ 5 ml/L decreased downy mildew severity substantially and stabilized onion yield. During the third year of the project research, the above mentioned best treatments were combined into an Integrated Disease Management Model (IDMM). This model was verified against Farmers' Own Practices (FOPs) of disease control. The multilocation testing of IDMM proved its superiority over FOPs in minimizing the disease attack and improving the crop yield.

The IDMM is easy to be adopted by the farmers as it does not require much professionalism. The use of fertilizers, good variety, optimum plant population and suitable pesticides is common among the farmers. With some modifications as

suggested in the model, these cultural practices can be conveniently used for downy mildew control.

With the use of appropriate cultural controls and limited fungicides, the total cost on the production and protection of onion crop will be reduced. It will also minimize losses from the environmental pollution which threaten human and crop health most frequently.

Through the use of IDMM, the productivity will be increased as well as the quality of onions will be improved. This may increase marketing of the produce inside and outside the country. The socio-economic condition of the farmer, within the country will be ameliorated.

1. INTRODUCTION

Onion as an important bulb vegetable crop of Pakistan was grown on an area of 85.5 thousands ha during 1998-99. In the NWFP, during this period, the area and production of the crop were 8.1 thousands ha and 120.5 thousands tonnes, respectively (Anonymous, 1999). Onion yield are very low in this province due to several constraints such as the use of low quality seed, imbalanced fertilizers, uneven irrigations and above all, the attack of various insect-pests and diseases.

In the NWFP, onion is attacked by several serious diseases i.e. downy mildew (Peronospora destructor), purple blotch (Alternaria porri), smut (Uromyces cepulae), grey mold (Botrytis sp.) and pink rot (Fusarium sp.). Among these, downy mildew is the most destructive disease which may reduce bulb yield upto 52-60% (Tahir, 1990; Brien, 1992). Initial symptoms of downy mildew are observed on leaves in the form of elongated patches that have grayish white furry growth during moist periods. Affected leaves first become pale green and later on yellow in colour. Diseased parts particularly leaf tips, fold over and collapse.

Several chemical, cultural and biological methods are used to control onion downy mildew. Teviodale et al (1980) reported that Ridomil controlled the disease on bulb as well as seed crop. Wilson (1980) concluded that Ridomil applied @ 100 g/ha was the best fungicide used against downy mildew. Boyadzhiev et al (1983) noted Ridomil very effective in reducing downy mildew infection in onions. Mir and Dhar (1988) observed that sprays of Metalaxyl were effective against downy mildew. Among the systemic fungicides, Metalaxyl and Cyomoxanil were note worthy (Palti, 1989). Krauthausen (1989) suggested that downy mildew of onion could be successfully controlled with Metalaxyl + Mancozeb, Triadimenol, Ethyltrianol or Procymidone. During 1989-90, seven fungicides viz. Antracol, Cuprisan 311-Super D, Dithane M-45, Nemispor, Penncozeb, Sandofan-M and Tri-Miltox forte were evaluated for their effectiveness against onion downy mildew. Highly significant control of disease was obtained with Ridomil MZ-72 WP and Sandofan M (Mohibullah, 1991). Tahir et al (1990) used eight fungicides viz. Antracol-70 WP, Liromanzeb-80WP, Daconil-75 WP, Ridomil MZ-72 WP, Duter-WP, Polyram combi, Tri-Miltox forte and Cupravit. Antracol was the most effective fungicide followed by Ridomil MZ-72 WP. The two fungicides caused increase in bulb yield by 52% and 42% over the untreated check, respectively. Issa et al (1981) used mixture of Zineb + Maneb + Copper to control the disease. Smith et al (1986) quoted that Mancozeb and Chlorothalonil completely controlled the disease. Brien (1992) reported that treatment containing Mancozeb gave the best control of downy mildew resulting in 60% increase in yield.

Beside chemical control, cultural methods have also been used to manage downy mildew. However, very little information in the literature is available about the effect of weed control, intercrops and irrigation intervals on downy mildew. Mohibullah (1991) determined the optimum level of plant density (140 plants/m^2) for the best control of the disease. He remarked that an increase in plant population from this optimum level resulted in higher intensities of downy mildew. The same author also investigated the effect of different NPK levels on severity of the disease. He reported the use of NPK 60:50:60 kg/ha as the best treatment that reduced the disease infection and gave acceptable yield (19.2 t/ha).

In order to have a novel approach to downy mildew control in onion, this project research was designed. The main objectives of this research were: (1) identification of best chemical and cultural management tactics for onion downy mildew and (2) development of an Integrated Disease Management Model (IDMM) for its appropriate control. With these objectives in mind, the project research was bifurcated into two phases. During the first phase, spread over a period of two years (1997-99), various experiments on downy mildew control were laid out to see the effect of different fungicides, plant populations, NPK levels. irrigation regimes, intercrops and weed control methods. Fungicides Ridomil, Dithane M-45 and Antracol; plant population @ 0.5 million plants/ha (cv. "Swat-1"), NPK fertilizer @ 120:90:60 kg/ha, eight irrigations/season, and herbicide "Roanstar" were selected on the basis of their best performance during the first phase. These treatments were combined into an IDMM for verification against the Farmers' Own Practices (FOPs) during the second phase (1999-2000). FOPs included the use of onion variety "Swat-1", plant density @ 0.9 million plants/ha, NPK fertilizer @ 100:0:0 kg/ha, biweekly irrigations, hand weeding and one spray of fungicide Dithane M-45 @ 300 g/100 L. Each treatment represented by a plot size of 250 m^2 was replicated four times in a Randomized Complete Block (RCB) design. Disease severity data were recorded each time after the application of fungicide, if any. Data on size, number and weight (yield) of bulbs were recorded at the time of harvest of the crop. All data were subjected to statistical analysis using Analysis of Variance (ANOVA) and Least Significant Difference (LSD) test. The results of these experiemtns are discused in the pages to follow.

2. RESULTS

2.1. Years 1997-99 Results

During 1997-99, different experiments were laid out to investigate best chemical and cultural practices for management of onion downy mildew. The results of testing various fungicides, plant densities, NPK levels, irrigation regimes, intercrops and weed control methods and their effect on disease severity and yield are described.

2.1.1. Synergy of fungicides in controlling downy mildew of onion

Fungicide application versus no application (untreated check) had a significant effect on disease severity, yield, number and size of onion bulbs. In every case, with fungicide application, there was a decrease in Area Under Disease Progress Curve (AUDPC) and increase in yield or its components. During 1997-98, the lowest AUDPC (173) was in treatment Antracol + Ridomil (Table 1) in contrast to treatment Dithane + Ridomil (T_{10}) with the lowest AUDPC value (154.2) during 1998-99 (Table 2). The treatments T_7 and T_{10} gave the highest bulb yield (17.9 and 21.9 t/ha), bulb number (40.3 and 41.3) and bulb size (4.7 and 5.9 cm) during the two consecutive years. On the other hand, AUDPC was the highest and bulb yield, number and size were the lowest in the untreated (control) check.

The combined application of two or more fungicides was better than their individual application indicating synergy between these fungicides. For example AUDPC was lower in treatment Dithane + Ridomil than that of either Dithane or Ridomil. Similarly, yield, number and size of bulbs were also lower in the latter two than the former treatment (Table 2).

The comparison of the two-year data indicates that AUDPC was lower and most other values were higher in the first than the second year experiments. This

Table 1. Effect of spray fungicides on severity of downy mildew (AUDPC) and yield of onion during 1997-98.

	Treatment	Mean AUDPC[1]	Mean[2] Bulb size (cm)	Mean Bulb number/m²	Mean Bulb yield (t/ha)
T_1	Antracol (@ 200g/100 L water)	262.5 BC (47.1)[3]	4.4 ABC[4] (15.8)[3]	35.3 ABC (58.3)[3]	16.2 ABC (10.9)[3]
T_2	Copper Oxychloride (@ 250g/100 L water)	337.7 B (31.9)	3.8 D (0.0)	26.8 CD (20.2)	15.6 BC (6.8)
T_3	Dithane M-45 (@ 300g/100 L water)	316.7 B (36.2)	4.1 CD (7.9)	26.3 CD (17.9)	15.6 BC (6.8)
T_4	Ridomil (@ 250g/100 L water)	204.2 CD (58.9)	4.6 AB (21.1)	36.8 AB (65.0)	16.8 AB (15.1)
T_5	Antracol + Copper Oxychloride (@ 200g+250g/100 L water)	308.3 B (37.9)	4.4 ABC (15.8)	31.0 ABCD (39.0)	15.4 BC (5.5)
T_6	Antracol + Dithane M-45 (@ 200g+300g/100 L water)	316.7 B (36.2)	4.3 ABCD (13.2)	25.0 D (12.1)	15.5 BC (6.2)
T_7	Antracol + Ridomil (@ 200g+250g/100 L water)	173.0 D (65.1)	4.7 A (23.7)	40.3 A (80.7)	17.9 A (22.6)
T_8	Copper Oxy. + Dithane M-45 (@ 250g+300g/100 L water)	329.3 B (33.6)	4.0 CD (5.3)	28.0 BCD (25.6)	15.9 BC (8.9)
T_9	Copper Oxychloride + Ridomil (@ 250g+250g/100 L water)	329.3 B (33.6)	4.2 BCD (10.5)	32.0 ABCD (43.5)	15.8 BC (8.2)
T_{10}	Dithane + Ridomil (@ 300g+250g/100 L water)	283.3 B (42.9)	4.1 BCD (7.9)	25.3 D (13.5)	16.3 ABC (11.6)
T_{11}	Antra.+Copper Oxy.+ Dith.+Rid. (@ 200g+250g+ 300g+250g/100 L water)	283.3 B (42.9)	4.1 BCD (7.9)	27.8 BCD (24.7)	15.9 BC (8.9)
T_{12}	No fungicide (Check)	496.3 A (--)	3.8 D (--)	22.3 D (--)	14.6 C (--)
	Mean	303.4	4.2	29.7	15.9
	LSD value	76.5	0.5	9.8	1.9
	CV (%)	14.9	6.2	22.9	8.3

[1] AUDPC (Area Under Disease Progress Curve) = $\sum_{n-1}^{1}\{(X_i+X_{i-1})/2\}\{t_i-t_{i-1}\}$

whereas X_i = present disease severity; X_{i-1} = previous disease severity and t_i-t_{i-1} = time difference between two consecutive disease severities.

[2] Mean represents average of four replications.

[3] Figures in parenthesis for AUDPC indicate decrease and those for yield, size and bulb number show increase over the untreated check.

[4] Figures followed by different letters are significantly different ($P<0.05$) from one another.

Table 2. Effect of spray fungicides on severity of downy mildew (AUDPC) and yield of onion during 1998-99.

	Treatment	Mean AUDPC[1]	Mean[2] Bulb size (cm)	Mean Bulb number/m^2	Mean Bulb yield (t/ha)
T_1	Antracol (@ 200g/100 L water)	394.0 BC[4] (28.4)[3]	4.6 CDE (17.9)[3]	34.3 BCDE (19.1)[3]	12.1 DE (12.0)[3]
T_2	Copper Oxychloride (@ 250g/100 L water)	458.5 AB (16.7)	4.5 DEF (15.4)	29.0 E (0.7)	13.2 CDE (22.2)
T_3	Dithane M-45 (@ 300g/100 L water)	433.5 ABC (21.2)	4.8 BCD (23.1)	35.3 ABCD (22.6)	14.8 BCDE (37.0)
T_4	Ridomil (@ 250g/100 L water)	175.1 DE (68.2)	5.1 B (30.8)	37.3 ABC (29.5)	17.8 B (64.8)
T_5	Antracol + Copper Oxychloride (@ 200g+250g/100 L water)	436.9 ABC (20.6)	4.3 EFG (10.3)	33.0 BCDE (14.6)	13.3 CDE (23.1)
T_6	Antracol + Dithane M-45 (@ 200g+300g/100 L water)	458.5 AB (16.7)	4.4 EF (12.8)	30.5 CDE (5.9)	13.5 CDE (25.0)
T_7	Antracol + Ridomil (@ 200g+250g/100 L water)	166.7 DE (69.7)	4.9 BC (25.6)	37.5 AB (30.2)	17.3 BC (60.2)
T_8	Copper Oxy. + Dithane M-45 (@ 250g+300g/100 L water)	462.7 AB (15.9)	4.2 FG (7.7)	32.0 BCDE (11.1)	11.1 D (2.8)
T_9	Copper Oxychloride + Ridomil (@ 250g+250g/100 L water)	302.2 CD (45.1)	4.2 FG (7.7)	35.3 ABCD (22.6)	15.2 BCD (40.7)
T_{10}	Dithane + Ridomil (@ 300g+250g/100 L water)	154.2 E (71.9)	5.9 A (51.3)	41.3 A (43.4)	21.9 A (102.8)
T_{11}	Antra.+Copper Oxy.+Dith.+Rid. (@ 200g+250g+300g+250g/100 L water)	250.0 DE (54.6)	4.5 DEF (15.4)	33.5 BCDE (16.3)	18.1 AB (67.6)
T_{12}	No fungicide (Check)	550.2 A (--)	3.9 G (--)	28.8 DE (--)	10.8 E (--)
	Mean	353.5	4.6	33.9	14.9
	LSD value	136.6	0.4	6.9	4.1
	CV (%)	136.6	5.7	14.3	19.1

[1] AUDPC (Area Under Disease Progress Curve) = $\sum_{n-1}^{1}\{(X_i+X_{i-1})/2\}\{t_i-t_{i-1}\}$

whereas X_i = present disease severity; X_{i-1} = previous disease severity and t_i-t_{i-1} = time difference between two consecutive disease severities.

[2] Mean represents average of four replications.

[3] Figures in parenthesis for AUDPC indicate decrease and those for yield. size and bulb number show increase over the untreated check.

[4] Figures followed by different letters are significantly different ($P<0.05$) from one another.

may be attributed to variation in inoculum density, soil fertility and weather condition during the two years.

2.1.2. Effect of host management on onion downy mildew control

In this complex experiment, the combined effect of different plant populations, NPK levels and irrigation regimes was studied on downy mildew severity and yield of onion. The lowest AUDPC value during the two seasons was recorded in T_{22}. In this treatment yield and bulb size were the greatest but the number of bulbs was lower than some other treatments. On the other hand, the highest AUDPC, low yield and small size and number of bulbs were recorded in T_{27}. Variability in disease severity and yield of the two treatments can be attributed only to NPK and plant population levels. This trend could be observed also in other treatments. The higher number of bulbs in T_{27} was due to higher plant population in this than T_{22}. However, the overall yield did not increase in T_{27} inspite of the fact that NPK dose was more in this treatment. Probably the level of NPK used in this treatment was not so effective in increasing the size of the large number of bulbs obtained from this treatment.

In most of the treatments, the effect of plant population was significant on disease severity and number of bulbs but non-significant on their weight and size. When T_{23} and T_{24} were compared with T_{22} (Table 3), the AUDPC value calculated and the number of bulbs counted in the former two treatments were significantly higher than that in T_{22}. However, the bulb size was greater in T_{22} than T_{23} and T_{24}. By increasing or decreasing NPK from the recommended level (120:90:60 kg/ha), the disease severity and bulb size increased significantly. On the other hand, weight and number of bulbs showed non-significant differences. The comparison of T_{25} and T_{19} with T_{22} showed this trend (Table 3). In T_{25}, where NPK level was higher than T_{22}, AUDPC was significantly more and bulb size significantly lesser

Table 3. Effect of host management on severity of downy mildew (AUDPC) and yield of onion during 1997-98.

Treatment		Mean AUDPC[1]	Mean[2] Bulb size (cm)	Mean Bulb number/m²	Mean Bulb yield (t/ha)
T_1	$(I_1F_1P_1)$	314.0 CDE[3]	4.2 C-J	16.3 M	8.5 B
T_2	$(I_1F_1P_2)$	314.0 CDE	4.3 B-I	20.7 KL	8.0 B
T_3	$(I_1F_1P_3)$	375.0 BC	4.5 B-G	24.3 H-K	10.2 AB
T_4	$(I_1F_2P_1)$	238.8 FG	3.8 IJ	26.7 E-J	11.2 AB
T_5	$(I_1F_2P_2)$	449.8 A	4.1 E-J	28.3 D-H	8.8 B
T_6	$(I_1F_2P_3)$	449.8 A	4.2 C-J	32.7 BC	9.4 B
T_7	$(I_1F_3P_1)$	238.8 FG	4.5 B-G	18.3 LM	9.7 B
T_8	$(I_1F_3P_2)$	314.0 CDE	4.6 B-E	23.0 JK	10.3 AB
T_9	$(I_1F_3P_3)$	375.0 BC	4.5 B-F	25.0 G-J	9.8 AB
T_{10}	$(I_2F_1P_1)$	300.0 DEF	3.9 G-J	25.0 G-J	5.3 B
T_{11}	$(I_2F_1P_2)$	375.0 BC	3.9 F-J	28.0 D-I	8.9 B
T_{12}	$(I_2F_1P_3)$	449.8 A	3.9 F-G	23.0 ABC	12.7 AB
T_{13}	$(I_2F_2P_1)$	314.0 CDE	4.3 B-J	24.0 IJK	12.0 AB
T_{14}	$(I_2F_2P_2)$	375.0 BC	3.9 HIJ	26.0 E-J	11.3 AB
T_{15}	$(I_2F_2P_3)$	413.8 AB	3.8 J	31.7 BCD	12.5 AB
T_{16}	$(I_2F_3P_1)$	252.7 EFG	4.2 C-J	27.3 E-I	9.5 B
T_{17}	$(I_2F_3P_2)$	314.0 CDE	4.4 B-H	30.0 CDE	9.6 B
T_{18}	$(I_2F_3P_3)$	375.0 BC	4.1 E-J	32.7 BC	9.2 B
T_{19}	$(I_3F_1P_1)$	314.0 CDE	4.7 BCD	29.3 C-F	10.7 AB
T_{20}	$(I_3F_1P_2)$	375.0 BC	4.5 B-E	32.0 BCD	10.0 AB
T_{21}	$(I_3F_1P_3)$	449.8 A	4.3 B-J	34.7 AB	10.3 AB
T_{22}	$(I_3F_2P_1)$	224.8 G	5.3 A	26.7 E-J	18.0 A

(Table 3 cont.)

Table 3(cont.) Effect of host management on severity of downy mildew (AUDPC) and yield of onion during 1997-98.

T_{23}	$(I_3F_2P_2)$	375.0 BC	4.2 D-J	29.0 C-G	13.0 AB
T_{24}	$(I_3F_2P_3)$	449.8 A	4.2 B-J	37.0 A	13.5 AB
T_{25}	$(I_3F_3P_1)$	347.3 CD	4.8 B	25.3 F-J	10.5 AB
T_{26}	$(I_3F_3P_2)$	375.0 BC	4.7 BCD	29.7 CDE	13.3 AB
T_{27}	$(I_3F_3P_3)$	449.8 A	4.7 BC	34.7 AB	9.2 B
	Mean	355.5	4.3	27.8	10.6
	LSD value	63.7	0.6	4.3	8.2
	CV (%)	10.8	7.9	9.4	46.9

I_1 = six irrigations/season; I_2 = seven irrigations/season and I_3 = eight irrigations/season
F_1 = NPK 90:60:30 kg/ha; F_2 = NPK 120:90:60 kg/ha and
F_3 = NPK 150:120:90 kg/ha
P_1 = 0.5 million plants/ha; P_2 = 0.75 million plants/ha and
P_3 = 1.0 million plants/ha

[1] AUDPC (Area Under Disease Progress Curve) = $\sum_{n-1}^{l}\{(X_i+X_{i-1})/2\}\{t_i-t_{i-1}\}$

whereas X_i = present disease severity; X_{i-1} = previous disease severity and t_i-t_{i-1} = time difference between two consecutive disease severities.

[2] Mean represents average of four replications.

[3] Figures followed by different letters are significantly different ($P<0.05$) from one another.

Table 4. Effect of host management on severity of downy mildew (AUDPC) and yield of onion during 1998-99.

Treatment		Mean AUDPC[1]	Mean[2] Bulb size (cm)	Mean Bulb number/m²	Mean Bulb yield (t/ha)
T_1	$(I_1F_1P_1)$	386.1 F[3]	4.6 DE	36.3 FGHIJ	7.0 E
T_2	$(I_1F_1P_2)$	425.1 E	4.5 DEF	43.3 FGHIJ	9.0 CDE
T_3	$(I_1F_1P_3)$	508.6 D	4.5 DEF	55.0 DEF	10.0 BCDE
T_4	$(I_1F_2P_1)$	427.7 E	3.9 IJK	33.7 GHIJ	10.7 BCDE
T_5	$(I_1F_2P_2)$	508.6 D	4.3 DEFG	46.3 FGHIJ	9.0 CDE
T_6	$(I_1F_2P_3)$	583.3 BC	3.9 IJK	70.7 BCD	10.0 BCDE
T_7	$(I_1F_3P_1)$	427.7 E	4.6 CD	29.7 IJ	6.5 E
T_8	$(I_1F_3P_2)$	508.6 D	4.4 DEF	33.7 GHIJ	6.7 E
T_9	$(I_1F_3P_3)$	583.3 BC	3.9 HIJ	69.3 CDE	11.3 BCDE
T_{10}	$(I_2F_1P_1)$	427.7 E	4.9 BC	35.7 FGHIJ	7.7 DE
T_{11}	$(I_2F_1P_2)$	508.6 D	4.0 GHIJ	47.0 FGHIJ	9.0 CDE
T_{12}	$(I_2F_1P_3)$	583.3 BC	3.5 MN	88.7 ABC	13.7 BC
T_{13}	$(I_2F_2P_1)$	427.7 E	4.6 CD	32.0 HIJ	10.5 BCDE
T_{14}	$(I_2F_2P_2)$	508.6 D	4.3 EFG	52.0 DEFGH	11.0 BCDE
T_{15}	$(I_2F_2P_3)$	600.0 B	3.8 IJKL	94.3 A	13.7 BC
T_{16}	$(I_2F_3P_1)$	427.7 E	5.1 B	28.7 J	8.7 CDE
T_{17}	$(I_2F_3P_2)$	508.6 D	4.3 EFGH	49.7 EFGHI	9.0 CDE
T_{18}	$(I_2F_3P_3)$	588.9 BC	3.7 JKLM	90.3 AB	11.7 BCDE
T_{19}	$(I_3F_1P_1)$	427.7 E	5.1 B	30.0 IJ	7.9 DE
T_{20}	$(I_3F_1P_2)$	508.6 D	4.2 FGH	53.7 DEFG	11.3 BCDE
T_{21}	$(I_3F_1P_3)$	600.0 B	3.5 LMN	76.7 ABC	10.3 BCDE
T_{22}	$(I_3F_2P_1)$	222.2 G	6.1 A	34.0 GHIJ	22.3 A

(Table 4 cont.)

Table 4 (cont.) Effect of host management on severity of downy mildew AUDPC and yield of onion during 1998-99.

T_{23}	$(I_3F_2P_2)$	508.6 D	4.3 EFGH	52.3 DEFGH	11.7 BCDE
T_{24}	$(I_3F_2P_3)$	600.0 B	3.4 N	92.7 A	10.3 BCDE
T_{25}	$(I_3F_3P_1)$	508.6 D	5.1 B	30.3 IJ	11.0 BCD
T_{26}	$(I_3F_3P_2)$	552.9 C	4.1 GHI	55.7 DEF	12.7 BCD
T_{27}	$(I_3F_3P_3)$	652.7 A	3.6 KLMN	83.0 ABC	14.9 D
	Mean	500.8	4.3	53.5	10.7
	LSD value	37.7	0.3	20.8	5.3
	CV (%)	4.5	4.4	23.4	30.3

I_1 = six irrigations/season; I_2 = seven irrigations/season and
I_3 = eight irrigations/season
F_1 = NPK 90:60:30 kg/ha; F_2 = NPK 120:90:60 kg/ha and
F_3 = NPK 150:120:90 kg/ha
P_1 = 0.5 million plants/ha; P_2 = 0.75 million plants/ha and
P_3 = 1.0 million plants/ha

[1] AUDPC (Area Under Disease Progress Curve) = $\sum_{n-1}^{1}\{(X_i+X_{i-1})/2\}\{t_i-t_{i-1}\}$

whereas X_i = present disease severity; X_{i-1} = previous disease severity and t_i-t_{i-1} = time difference between two consecutive disease severities.

[2] Mean represents average of four replications.

[3] Figures followed by different letters are significantly different from one another.

than that in T_{22}. The same was the case when T_{19} and T_{22} were compared with one another.

Irrigation regimes had significant effect on downy mildew severity, yield and bulb size but not on bulb number. When treatments T_{13} and T_4 were compared with T_{22} (Table 3), there was an increase in AUDPC in T_{13} and T_4 over T_{22}. However, the yield and bulb size were lower in the former two treatments than the latter one. In contrast to this, bulb number was more in T_{13} and T_4 than T_{22}. This trend was also observed among other treatments such as T_5, T_{14} and T_{23}.

The effect of plant population, NPK fertilizer and irrigation regimes on disease severity was very prominent. This was because dense planting, sub or above optimal NPK levels and more number of irrigations provided conducive environment for severe disease development. However, they had a variable effect on yield components. Plant population affected bulb number, NPK fertilizers bulb size and irrigations both bulb size and weight.

Non-significant increase in yield of T_{22} over other treatments due to plant population and NPK fertilizers indicated their less effect on size and number of bulbs, respectively. In contrast to this, irrigation regimes affected yield inspite of its non-significant effect on bulb number. The variable effect of host management practices on disease severity and yield necessitated the identification of a treatment like T_{22} (plant population = 0.5 million plants/ha; NPK = 120:90:60 kg/ha and 8 irrigations) which may guarantee the disease control and higher productivity in onions.

2.1.3. Influence of intercropping on downy mildew control in onion

In this experiment, the effect of different crops, grown alone and in combination with one another, was studied on the severity of downy mildew and yield of onion. Significant differences ($P<0.05$) were observed among the

Table 5. Effect of intercropping on severity of downy mildew (AUDPC) and yield of onion during 1997-98.

Treatment	Mean AUDPC[1]	Mean[2] Bulb size (cm)	Mean Bulb number/m²	Mean Yield (t/ha)	Mean Pea yield (t/ha)	Mean Garlic yield (t/ha)	Mean Wheat yield (t/ha)
T_1 (Onion)	237.7 B[3]	4.8 A	29.0 A	16.7 A	0.0 B	0.0 C	0.0 C
T_2 (Onion+Garlic)	283.3 A	3.9 BC	19.3 B	9.3 AB	0.0 B	5.8 A	0.0 C
T_3 (Onion+Pea)	237.7 B	4.7 A	20.0 B	9.4 AB	6.0 A	0.0 C	0.0 C
T_4 (Onion+Wheat)	273.0 A	3.7 C	8.0 D	1.4 B	0.0 B	0.0 C	4.5 AB
T_5 (Onion+Pea+Garlic)	273.0 A	4.1 BC	15.0 BC	5.8 B	6.8 A	6.2 A	0.0 C
T_6 (Onion+Pea+Wheat)	237.7 B	3.8 BC	13.0 CD	8.5 AB	6.4 A	0.0 C	4.9 A
T_7 (Onion+Garlic+Wheat)	237.7 B	3.9 BC	18.5 B	6.3 B	0.0 B	6.4 A	4.3 B
T_8 (Onion+Pea+Garlic+ Wheat)	283.3 A	4.1 B	15.5 BC	7.3 B	6.9 A	3.4 B	4.5 AB
Mean	257.9	4.1	17.3	8.1	3.3	2.7	2.3
LSD value	28.6	0.4	5.1	8.3	1.5	0.8	0.5
CV (%)	6.3	6.8	20.2	69.9	30.2	19.7	16.1

[1] AUDPC (Area Under Disease Progress Curve) = $\sum_{n-1}^{1}\{(X_i+X_{i-1})/2\}\{t_i-t_{i-1}\}$

whereas X_i = present disease severity; X_{i-1} = previous disease severity and t_i-t_{i-1} = time difference between two consective disease severities.

[2] = Mean represents average of four replications.

[3] = Figures followed by different letters are significantly different ($P<0.05$) from one another.

Table 6. **Effect of intercropping on severity of downy mildew (AUDPC) and yield of onion during 1998-99.**

Treatment	Mean AUDPC[1]	Mean[2] Bulb size (cm)	Mean Bulb number/m^2	Mean Yield (t/ha)	Mean Pea yield (t/ha)	Mean Garlic yield (t/ha)	Mean Wheat yield (t/ha)
T_1 (Onion)	419.0 C[3]	4.9 A	35.0 A	15.9 A	0.0 B	0.0 D	0.0 B
T_2 (Onion+Garlic)	479.2 B	4.0 BC	24.0 B	9.8 BC	0.0 B	11.0 A	0.0 B
T_3 (Onion+Pea)	464.7 B	4.8 A	25.0 B	8.2 BC	5.3 A	0.0 D	0.0 B
T_4 (Onion+Wheat)	525.2 A	3.4 D	14.5 C	3.9 D	0.0 B	0.0 D	5.3 A
T_5 (Onion+Pea+Garlic)	525.2 A	4.2 B	24.8 B	10.3 B	6.1 A	8.9 B	0.0 B
T_6 (Onion+Pea+Wheat)	525.2 A	3.7 CD	19.8 BC	9.1 BC	4.3 A	0.0 D	5.8 A
T_7 (Onion+Garlic+Wheat)	525.2 A	3.7 CD	19.3 BC	5.8 CD	0.0 B	9.7 B	4.5 A
T_8 (Onion+Pea+Garlic+Wheat)	525.2 A	4.1 B	20.0 BC	8.3 BC	6.1 A	3.4 C	5.0 A
Mean	498.6	4.1	22.8	8.9	2.7	4.1	2.6
LSD value	19.5	0.3	6.6	4.2	1.9	1.1	1.9
CV (%)	2.2	5.6	19.8	32.0	47.3	17.9	44.5

[1] AUDPC (Area Under Disease Progress Curve) = $\sum_{n-1}^{1}\{(X_i+X_{i-1})/2\}\{t_i-t_{i-1}\}$

whereas X_i = present disease severity; X_{i-1} = previous disease severity and t_i-t_{i-1} = time difference between two consective disease severities.

[2] = Mean represents average of four replications.

[3] = Figures followed by different letters are significantly different ($P<0.05$) from one another.

different treatments for AUDPC. The lowest value was recorded in treatment where onion was planted alone (Tables 5 & 6). On the other hand, the higher AUDPC was calculated for the treatments where the onion was planted in combination with wheat or other crops. Difference between the highest and lowest AUDPC values ranged from 45.6-106.2%. Treatment with the lowest AUDPC (T_1) showed the highest yield and greatest size and number of bulbs. In contrast to this, these values were the lowest in treatment having onion + wheat planting. Onion yield was also affected adversely when it was planted in combination with pea. Probably these crops facilitated conducive environment for the severe development of downy mildew and reduced onion yield due to their shadding effect on the target crop. This was evident from the AUDPC value for the treatment onion + wheat or onion + pea in this experiment. The AUDPC was also higher and size, number and yield of bulbs were lower in treatment with onion + garlic (T_2). Garlic might have proved apt to the attack of the disease, thus increasing the inoculum of the fungus and lowering onion yield. All this indicates that intercropping of onion with other crops is not useful to reduce downy mildew infection.

2.1.4. Relative efficacy of weed control methods in controlling onion downy mildew

The different treatments were significantly different ($P < 0.05$) in their effect on disease severity, size, number and yield of bulbs during the two years. During the first year, AUDPC was the lowest in treatment where no herbicide was applied but weeding was done (Table 7). As against this, it was the highest in treatment Double Zero during the second year (Table 8). In the latter year, the lowest AUDPC was calculated for T3 where "Roanstar" @ 5 ml/L and hand weeding were used. This treatment also showed the highest yield and number and size of bulbs. Data in Table 7 indicate that treatments with herbicide 2,4-D caused adverse

Table 7. Effect of weed control methods on severity of downy mildew (AUDPC) and yield of onion during 1997-98.

	Treatment	Mean AUDPC[1]	Mean[2] Bulb size (cm)	Mean Bulb number/m²	Mean Bulb yield (t/ha)
T_1	2.4-D (@ 3.5g/L + weeding)	391.8 D[3]	3.2 C	11.3 C	2.9 C
T_2	2.4-d (@ 3.5g/L + no weeding)	465.8 BC	2.6 D	10.5 D	2.8 C
T_3	2.4-D (@ 4.5g/L + weeding	432.5 CD	2.9 CD	9.5 E	2.7 C
T_4	2.4-D (@ 4.5g/L + no weeding)	519.8 AB	2.6 D	9.0 EF	2.5 C
T_5	2.4-D (@ 5.5g/L + weeding)	496.8 BC	2.6 D	8.6 FG	2.6 C
T_6	2.4-D(@ 5.5g/ L + no weeding)	579.5 A	2.6 D	8.0 G	2.5 C
T_7	No herbicide + weeding (Check 1)	293.0 E	4.6 A	28.3 A	15.2 A
T_8	No herbicide + no weeding (Double zero - Check 2)	475.2 BC	3.7 B	25.9 B	10.1 B
	Mean	456.8	3.1	13.9	5.2
	LSD value	68.2	0.4	0.6	1.5
	CV (%)	7.9	11.9	4.4	27.9

[1] AUDPC (Area Under Disease Progress Curve) = $\sum_{n-1}^{1}\{(X_i+X_{i-1})/2\}\{t_i-t_{i-1}\}$

whereas X_i = present disease severity; X_{i-1} = previous disease severity and t_i-t_{i-1} = time difference between two consective disease severities.

[2] = Mean represents average of four replications.
[3] = Figures followed by different letters are significantly different ($P<0.05$) from one another.

Table 8. Effect of weed control methods on severity of downy mildew (AUDPC) and yield of onion during 1998-99.

	Treatment	Mean AUDPC[1]	Mean[2] Bulb size (cm)	Mean Bulb number/m^2	Mean Bulb yield (t/ha)
T_1	Roanstar (@ 4 ml/L + weeding)	445.0 CD[3]	4.8 B	30.8 BC	12.8 AB
T_2	Roanstar (@ 4 ml/L + no weeding)	516.8 AB	3.9 C	25.9 CD	10.1 BC
T_3	Roanstar (@ 5 ml/L + weeding)	294.0 E	6.1 A	36.9 A	16.3 A
T_4	Roanstar (@ 5 ml/L + no weeding)	485.5 BC	4.7 B	27.1 CD	10.1 BC
T_5	Roanstar (@ 6 ml/L + weeding)	412.7 D	4.8 B	27.0 CD	9.8 BC
T_6	Roanstar (@ 6 ml/L + no weeding)	520.0 AB	3.9 C	22.9 DE	8.3 C
T_7	No herbicide + weeding (Check 1)	326.2 E	6.1 A	34.8 AB	16.0 A
T_8	No herbicide + no weeding (Double zero - Check 2)	560.7 A	3.4 D	20.5 E	6.4 C
	Mean	445.1	4.7	28.2	11.2
	LSD value	56.8	0.3	5.4	3.8
	CV (%)	6.8	5.9	18.6	33.3

[1] AUDPC (Area Under Disease Progress Curve) = $\sum_{n-1}^{1}\{(X_i+X_{i-1})/2\}\{t_i-t_{i-1}\}$

whereas X_i = present disease severity; X_{i-1} = previous disease severity and t_i-t_{i-1} = time difference between two consective disease severities.

[2] = Mean represents average of four replications.

[3] = Figures followed by different letters are significantly different ($P<0.05$) from one another.

effect on disease severity and yield. This was due to its phytotoxic effect on the crop in the field. This herbicide was used hesitatingly in the experiment due to non availability of berbicide Roanstar in the market at the time of the lay out of the experiment. However, with the application of "Roanstar" during the next year the situation changed altogether. Treatment having this herbicide in combination with weeding showed better performance than the untreated controls (checks 1 & 2).

Herbicide Roanstar used @ 5 ml/L proved optimum to control weeds, reduce the disease severity and increase onion yield. Manual weeding alone or in combination with herbicide Roanstar was better than no-weeding. Weed control through either method was assumed to be essential for reduction of disease inoculum and weed population. It is why important that farmers growing onions must practice weed control. A resourceful farmer can use herbicide as well as hand weeding. However, the poor grower has also the choice to practice hand weeding only for the control of downy mildew.

2.2. Year 1999-2000 Results

During this year, an experiment on the comparison of IDMM with FOPs at different locations was laid out.

2.2.1. Effect of Multilocation testing of IDMM versus FOPs on downy mildew severity and yield in onion

Data on disease severity expressed as AUDPC, bulb size, bulb number and onion yield dare presented.

2.2.1.1. Area Under Disease Progress Curve (AUDPC)

Significant differences ($P < 0.05$) occurred in AUDPC of IDMM and FOPs at different locations (Table 9). In treatments IDMM and FOPs, the lowest value was recorded at Zoor Mandi while the highest at Zakhi Qabristan and Miana, respectively. Difference between the highest and the lowest value was 66.5% for

Table 9. Effect of multilocation testing of IDMM versus FOPs on severity of onion downy mildew (AUDPC) during 1999-2000.

	Location	Area under disease progress curve (AUDPC[1])		Decrease of IDMM than FOPs
		IDMM[2]	FOPs[3]	
1	Miana	177.0 A[4]	496.5 A	-319.5
2	Zarif Shah	116.0 B	256.8 B	-140.8
3	Zakhi Qabristan	188.2 A	491.2 A	-303.0
4	Zoor Mandi	113.0 B	245.2 B	-132.2
	Mean	148.5	372.4	223.9
	LSD value	42.1	99.0	--
	CV (%)	14.2	13.3	--

[1] AUDPC (Area Under Disease Progress Curve) = $\sum_{n-1}^{1}\{(X_i+X_{i-1})/2\}\{t_i-t_{i-1}\}$

whereas X_i = present disease severity; X_{i-1} = previous disease severity and t_i-t_{i-1} = time difference between two consective disease severities.

[2] IDMM (Integrated Disease Management Model) = Using NPK fertilizer @ 120:90:60 kg/ha + 0.5 million plants/ha + eight irrigations + herbicide Roanstar @ 5 g/L water and hand weeding.

[3] FOPs (Farmers Own Practices) = Using NPK fertilizer @ 100:0:0 kg/ha + 0.9 million plants/ha + biweekly irrigation + hand weeding + one spray of fungicide Dithane M-45 @ 300 g/100 L water.

[4] Values followed by different letters are significantly different ($P<0.05$) from one another.

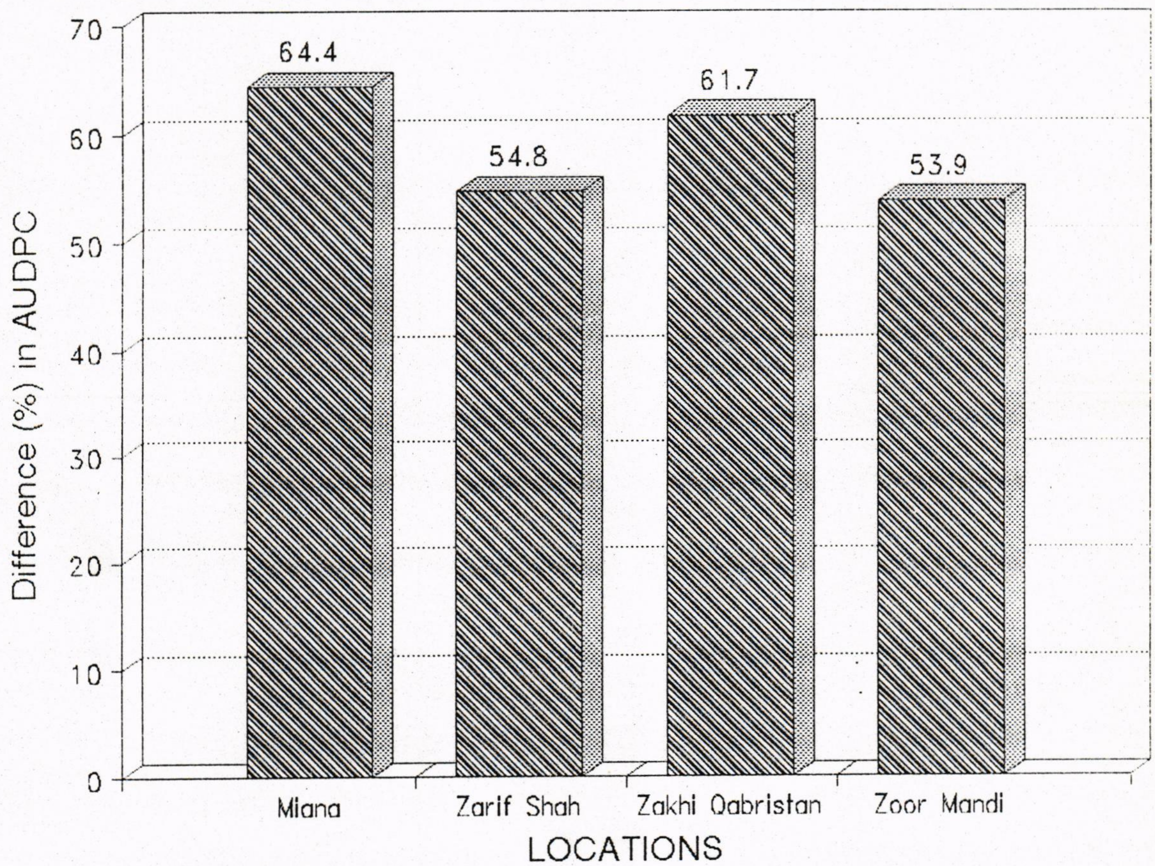

Fig.1. Multilocation testing of IDMM vs FOPs showing difference (%) in AUDPC during 1999-2000.

IDMM and 102.5% for FOPs. Locationwise, the lowest difference (53.9%) was at Zoor Mandi and the highest (64.4%) at Miana when the highest and lowest AUDPC values of the same locaiton were compared (Fig.1). Again the lowest value of IDMM and FOP was lower than across location mean by 39.4% and 51.9%, respectively. All this indicated the treatment X location effect whereas IDMM caused more reduction than FOP in disease severity at the test sites.

2.2.1.2. Bulb Size

It showed variation in the same treatment tested at different locations. In both the treatments, the greatest bulb size treatments was recorded at Zoor Mandi. It was higher by 16.9% and 23.8% than the lowest values in the IDMM and FOPs, respectively. However, the former was lower by 6.9% than the latter (Table 10). During 1999-2000, bulb size was greater by 95.2-115.6% in the IDMM than FOP at different locations. The lowest difference was at Zarif Shah and the highest at Miana (Fig.2).

Mean of the greatest and across location values differed by 8.4% in IDMM and 11.9% in FOPs. In this case the mean of IDMM was nearer to the overall mean than that of FOPs. Thus the small difference between the greatest and the lowest values and that of the IDMM with the overall mean. In the former case bulbs of uniform and bigger size were produced at different locations. This facilitates the grading of bulbs and their quick and timely supply to the market.

2.2.1.3. Bulb Number

Non-significant differences ($P>0.05$) were recorded among the different locations showing the reduction of the same treatment. However, different treatments at the same location showed variation that ranged from 71.6-74.5% (Fig.3). The highest difference was at Zoor Mandi (74.5%) where this number

Table 10. Effect of multilocation testing of IDMM versus FOPs on bulb size of onion during 1999-2000.

Location		Mean[1] Bulb size (cm)		Increase of IDMM over FOPs (cm)
		IDMM[2]	FOPs[3]	
1	Miana	6.9 B[4]	3.2 B	+3.7
2	Zarif Shah	8.2 A	4.2 A	+4.0
3	Zakhi Qabristan	7.0 B	3.3 B	+3.7
4	Zoor Mandi	8.3 A	4.2 A	+4.1
	Mean	7.9	3.7	3.9
	LSD value	0.2	0.2	--
	CV (%)	1.2	4.7	--

[1] Mean represents average of 4 replications.

[2] IDMM (Integrated Disease Management Model) = Using NPK fertilizer @ 120:90:60 kg/ha + 0.5 million plants/ha + eight irrigations + herbicide Roanstar @ 5 g/L water and hand weeding.

[3] FOPs (Farmers Own Practices) = Using NPK fertilizer @ 100:0:0 kg/ha + 0.9 million plants/ha + biweekly irrigation + hand weeding + one spray of fungicide Dithane M-45 @ 300 g/100 L water.

[4] Values followed by different letters are significantly different ($P < 0.05$) from one another.

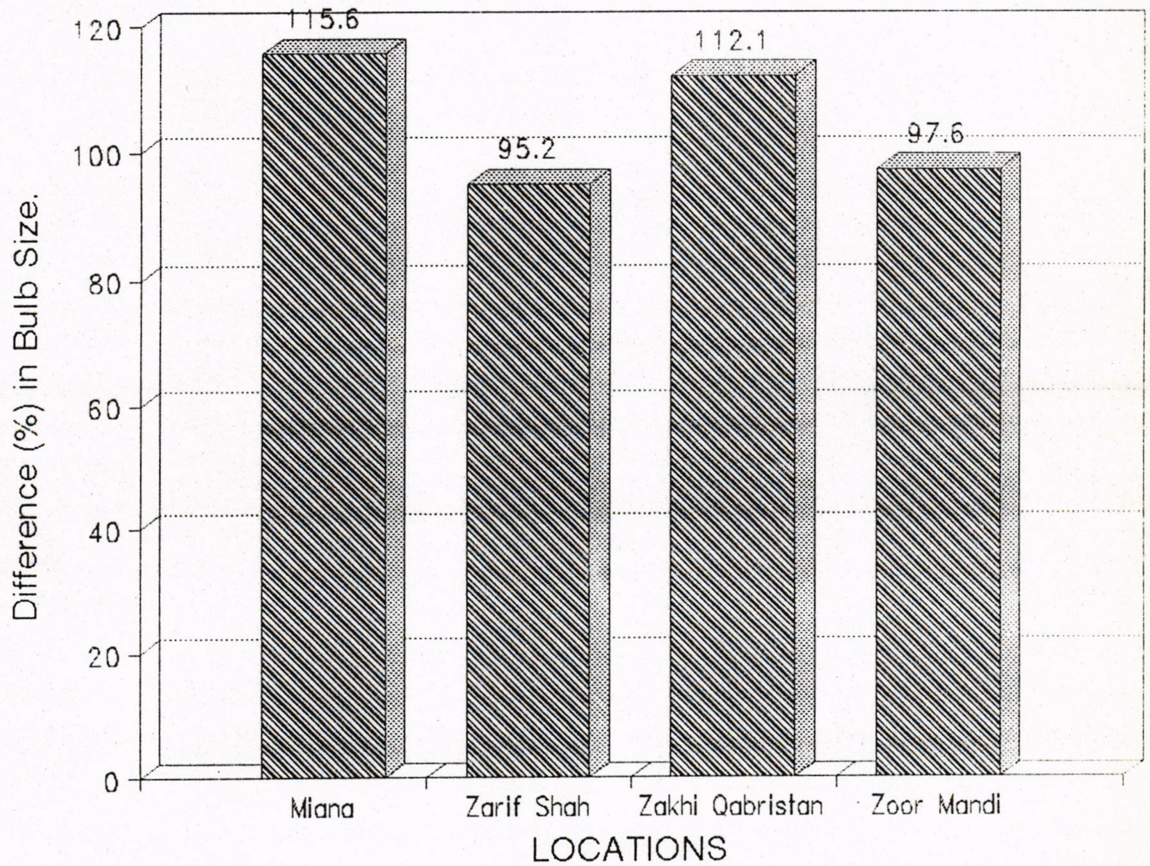

Fig.2. Multilocation testing of IDMM vs FOPs showing difference (%) in bulb size during 1999-2000.

Table 11. Effect of multilocation testing of IDMM versus FOPs on bulb number of onion during 1999-2000.

Location	Mean[1] Number of bulbs		Increase of IDMM over FOPs
	IDMM[2]	FOPs[3]	
1 Miana	49.6 NS[4]	85.7 NS	+36.1
2 Zarif Shah	49.9 NS	86.3 NS	+36.4
3 Zakhi Qabristan	49.7 NS	85.3 NS	+35.6
4 Zoor Mandi	49.5 NS	86.4 NS	+36.9
Mean	49.7	85.9	36.3
LSD value	--	--	--
CV (%)	1.4	3.3	--

[1] Mean represents average of 4 replications.

[2] IDMM (Integrated Disease Management Model) = Using NPK fertilizer @ 120:90:60 kg/ha + 0.5 million plants/ha + eight irrigations + herbicide Roanstar @ 5 g/L water and hand weeding.

[3] FOPs (Farmers Own Practices) = Using NPK fertilizer @ 100:0:0 kg/ha + 0.9 million plants/ha + biweekly irrigation + hand weeding + one spray of fungicide Dithane M-45 @ 300 g/100 L water.

[4] NS = Non significant differences calculated by LSD test ($P<0.05$).

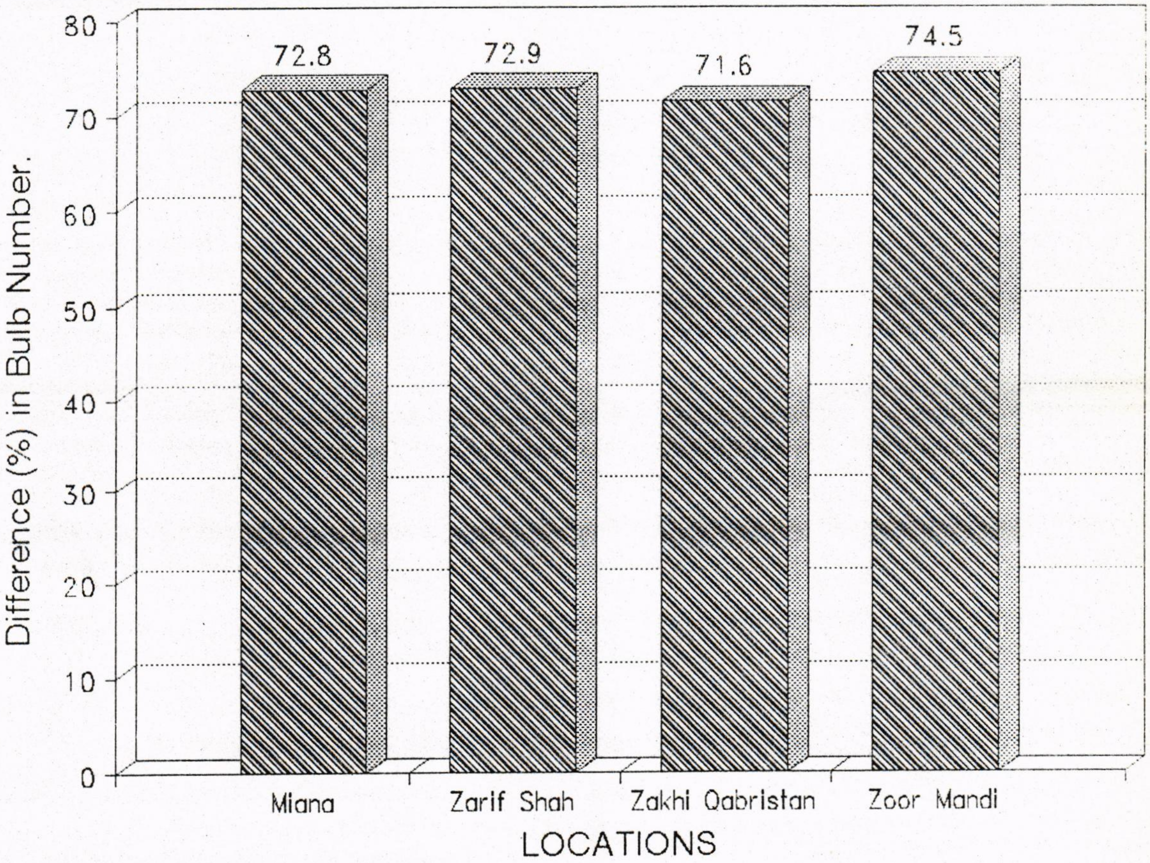

Fig.3. **Multilocation testing of IDMM vs FOPs showing difference (%) in bulb number during 1999-2000.**

was the lowest in IDMM and the highest in FOPs. By using high plant population in the FOPs treatment, the farmers got more number of bulbs per unit area. However, due to non-availability of sufficient space and more competition, the bulb size decreased affecting the yield adversely. In the IDMM, inspite of lower number, the size of bulbs was greater and their yield was more than FOPs which showed the added advantage of the former over the latter. In treatment like FOPs, the maintenance of plant population above optimum level is uneconomical. This requires more seed, space, fertilizer, weeding and water for irrigation. Above all, dense planting provides more conducive environment for downy mildew development, a threat to successful production of onions in this province.

2.2.1.4. Bulb yield

Significant differences ($P < 0.05$) in yield were observed between and among the different treatments and locations (Table 12). In both the treatments, the highest yield was recorded at Zoor Mandi. However, the yield in IDMM was higher by 82.2% than that of FOPs indicating treatment effect (Fig.4). Its further confirmation was made from the difference between the highest and lowest yield in each treatment. It was 21.1% in IDMM and 17.5% in FOPs. Similarly, location effect was evident from the increase in yield of one location over the other. Bulb yield recorded at Zoor Mandi was more than some other locations by 18.9-21.1% in IDMM and 15.7-17.5% in FOPs. The yield obtained at Zoor Mandi was higher by 10.1% in IDMM and 9.1% in FOPs than its respective across locations means. This proved the superiority of IDMM over FOP in increasing onion productivity in the test areas.

Table 12. Effect of multilocation testing of IDMM versus FOPs on bulb yield of onion during 1999-2000.

Location		Mean[1] Bulb yield (t/ha)		Increase of IDMM over FOPs (cm)
		IDMM[2]	FOPs[3]	
1	Miana	47.6 B[4]	27.3 B	+20.3
2	Zarif Shah	60.2 A	32.0 A	+28.2
3	Zakhi Qabristan	48.9 B	27.9 B	+21.0
4	Zoor Mandi	60.3 A	33.1 A	+27.2
	Mean	54.2	30.1	4.2
	LSD value	2.2	1.4	--
	CV (%)	1.9	3.5	--

[1] Mean represents average of 4 replications.

[2] IDMM (Integrated Disease Management Model) = Using NPK fertilizer @ 120:90:60 kg/ha + 0.5 million plants/ha + eight irrigations + herbicide Roanstar @ 5 g/L water and hand weeding.

[3] FOPs (Farmers Own Practices) = Using NPK fertilizer @ 100:0:0 kg/ha + 0.9 million plants/ha + biweekly irrigation + hand weeding + one spray of fungicide Dithane M-45 @ 300 g/100 L water.

[4] Values followed by different letters are significantly different ($P<0.05$) from one another.

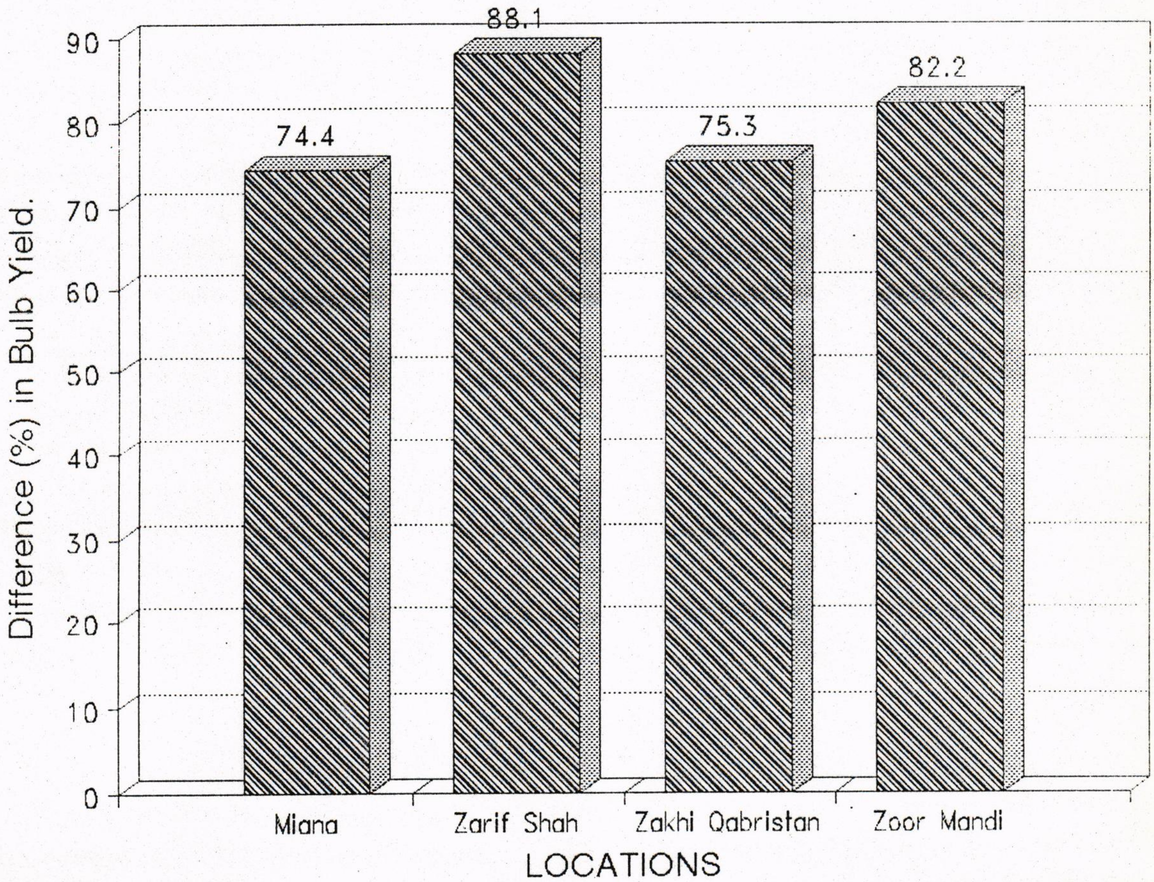

Fig.4. Multilocation testing of IDMM vs FOPs showing difference (%) in bulb yield during 1999-2000.

3. DISCUSSION

Downy mildew has been observed to cause severe losses to onion yields in the NWFP where onion is an important agricultural commodity. This disease not only reduces the yield but also adversely affects the quality in the form of misshapen bulbs. Such bulbs fetch low price in the market and show reduced keeping quality during storage. On the other hand, low yields are obtained when the number and size of bulbs are reduced. In order to control the disease and minimize its losses, farmers frequently use different fungicides. However, the rapid increase in fungicide prices, their less availability in the market and the ignorance of farmers about their proper use or the use of non-chemical methods have made downy mildew control difficult. Keeping these points in view, this project research was aimed to investigate proper chemical and non-chemical controls and to combine them into an Integrated Disease Management Model for multilocation testing.

Evaluation of several management tactics resulted in identifying suitable fungicide (Dithane M-45 + Ridomil @ 300 g/100 L + 250 g/100 L), plant population level (@ 0.5 million plants/ha); NPK fertilizer (@ 120:90:60 kg/ha), post emergence herbicide Roanstar (@ 5 ml/L) and eight biweekly irrigations. These best control measures tested on cv. "Swat-1" in separate experiments during the first two years of the project research, were combined into an IDM Model and verified in the third year against the Farmers' Own Practices (FOPs). This model showed superiority over the FOPs at several locations. Its use caused decrease in disease severity and increase in size, number and yield of bulbs. However, due to some limitations of time and funds, testing of this improved model was restricted to only one season and four different locations. Would it have been allowed more time and space, IDMM results would have been obtained for more locations and a number of years.

More emphasis has been envisaged through this project research on the use of non-chemical or low-chemical methods of downy mildew control. Normally farmers are more ignorant of cultural controls because these methods are generally considered to be production rather than protection strategies. However, the results of this research emphasize the importance of these cultural practices. With some modifications as suggested in the proposed IDM Model, these agronomic practices can be used to support the plant growth as well as to protect it from the attack of downy mildew.

Through the use of balanced fertilizers, optimum level of plant density, proper irrigation regimes, weed control in an adoptable onion variety, the good health of plants can be ensured to overcome the fungus infection. The control of downy mildew with small quantity of fungicides coupled with cultural practices guarantees the protection of environmental pollution which is direly needed for the survival of man as well as plants on the surface of the earth. The IDMM approach facilitates the easy accessibility of the farmers to the use of fertilizers, plant populations, irrigations and weed control. Less crop inputs will be required to produce and protect onions. Spending extra money on purchase of fungicides will be curtailed. More income and less environmental hazards will be ensured.

The findings of this research shall encourage the growers to bring more pieces of land under onion cultivation which were either lying barren or under less productive crops. Areas abandoned due to downy mildew attack will be reused for onion husbandry, resulting in increased productivity and production of onion.

Successful agro-marketing will be encouraged if regular supply is made of good quality onions. This is possible through the use of this IDM Model as disease free, large size bulbs can be supplied to the market in sufficient quantity and at reasonable rates.

The findings of this research can benefit other scientists such as agronomists, plant breeders, plant protectionists and agricultural economists. These results can be used for exploratory studies in these areas. Teachers and students may show interest in getting information for their academic persuits from this project research.

4. CONCLUSION

The following conclusions can be made from this project research:

1. The synergy of Ridomil with Antracol or Dithane M-45 proved to be the best in reducing downy mildew attack in onion.

2. Host management with 120:90:60 kg/ha, 0.5 million plants/ha and eight irrigations caused significant decrease in the disease infection.

3. Intercropping wheat, pea or garlic with onion did not affect downy mildew severity significantly.

4. Post emergence application of herbicide "Roanstar" @ 5 ml/L killed most of the weeds. The disease attack was reduced subsequently.

5. The Integrated Disease Management Model (IDMM) had a superiority over the Farmers' own Practices (FOPs) in reducing downy mildew severity by 54-64% and increasing size, number and yield of bulbs by 105.4, 72.9 and 80.1%, respectively.

5. NEED FOR ADDITIONAL RESEARCH

1. Relevance of planting, transplantation time, rotation and field sanitation to downy mildew attack.

2. Efficacy of new systemic pesticides in controlling the disease.

3. Identification of better sources of disease resistance.

4. Ecological zoning of the disease.

5. Further testing of the proposed IDM Model at several othe rlocations and for many years.

6. PUBLICATIONS

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2. Shabeer Ahmad and Hakim Khan. 2000. Influence of host management on downy mildew control in onions (Accepted for Publication in Pak. J. Biological Sciences).
3. Shabeer Ahmad and Hakim Khan. 2000. Development of an Integrated Disease Management Model (IDMM) for control of onion downy mildew in the NWFP, Pakistan (Submitted for Publication).

7. LIST OF SCIENTISTS

Name	Designation	Percentage of time devoted to the project work
1. Dr. Shabeer Ahmad	Principal Investigator	33%
2. Mr. Hakim Khan	Research Associate	100%
3. Mr. Muhammad Ayaz	Typing/Account work	33%

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APPENDIX-I

Table 1. Synergy of fungicides in controlling downy mildew of onion during 1997-98 (Mean Disease Severity).

	Treatment	Disease Severity Scoring (%)				Mean	Mean AUDPC calculated
		7.4.98	17.4.98	27.4.98	7.5.98		
T_1	Antracol (@ 200g/100 L water)	7.5	15.0 BC*	35.0 BC	50.0 BC	26.9	262.5 BC
T_2	Copper Oxychloride (@ 250g/100 L water)	8.8	20.0 B	42.5 AB	68.8 AB	35.0	337.7 B
T_3	Dithane M-45 (@ 300g/100 L water)	7.5	17.5 BC	42.5 AB	62.5 AB	32.5	316.7 B
T_4	Ridomil (@ 250g/100 L water)	7.5	12.5 BC	27.5 BC	35.0 C	20.6	204.2 CD
T_5	Antracol + Copper Oxychloride (@ 200g+250g/100 L water)	7.5	15.0 BC	42.5 AB	62.5 AB	31.9	308.3 B
T_6	Antracol + Dithane M-45 (@ 200g+300g/100 L water)	7.5	17.5 BC	42.5 AB	62.5 AB	32.5	316.7 B
T_7	Antracol + Ridomil (@ 200g+250g/100 L water)	8.8	10.0 C	20.0 C	35.0 C	18.5	173.0 D
T_8	Copper Oxy. + Dithane M-45 (@ 250g+300g/100 L water)	8.8	17.5 BC	42.5 AB	68.8 AB	34.4	329.3 B
T_9	Copper Oxychloride + Ridomil (@ 250g+250g/100 L water)	8.8	17.5 BC	42.5 AB	68.8 AB	34.4	329.3 B
T_{10}	Dithane + Ridomil (@ 300g+250g/100 L water)	7.5	15.0 BC	35.0 BC	62.5 AB	30.0	283.3 B
T_{11}	Antra.+Copper Oxy.+Dith.+Rid. (@ 200g+250g+300g+250g/100 L water)	7.5	15.0 BC	35.0 BC	62.5 AB	30.0	283.3 B
T_{12}	No fungicide (Check)	10.0	42.0 A	62.5 A	78.8 A	48.3	496.3 A
	Mean	8.1	17.9	39.2	59.8	31.3	303.4
	LSD value	-	9.5	21.3	18.9	-	76.5
	CV (%)	32.3	36.9	37.7	22.0	-	14.9

[1] Figures followed by different letters are significantly different ($P < 0.05$) from one another.

Table 2. Synergy of fungicides in controlling downy mildew of onion during 1997-98 (Replicated data on bulb size).

	Treatment	Replications				Mean
		1	2	3	4	
T_1	Antracol (@ 200g/100 L water)	4.5	3.8	4.6	4.6	4.4 ABC[1]
T_2	Copper Oxychloride (@ 250g/100 L water)	3.8	3.8	3.8	4.1	3.8 D
T_3	Dithane M-45 (@ 300g/100 L water)	3.8	4.3	4.2	3.9	4.1 CD
T_4	Ridomil (@ 250g/100 L water)	4.6	4.8	4.6	4.3	4.6 AB
T_5	Antracol + Copper Oxychloride (@ 200g+250g/100 L water)	4.6	3.9	4.4	4.5	4.4 ABC
T_6	Antracol + Dithane M-45 (@ 200g+300g/100 L water)	4.3	4.4	3.9	4.4	4.3 ABCD
T_7	Antracol + Ridomil (@ 200g+250g/100 L water)	4.8	4.8	4.5	4.6	4.7 A
T_8	Copper Oxy. + Dithane M-45 (@ 250g+300g/100 L water)	3.8	4.1	4.1	4.1	4.0 CD
T_9	Copper Oxychloride + Ridomil (@ 250g+250g/100 L water)	4.2	3.8	4.6	4.2	4.2 BCD
T_{10}	Dithane + Ridomil (@ 300g+250g/100 L water)	3.8	4.5	4.1	3.8	4.1 BCD
T_{11}	Antra.+Copper Oxy.+Dith.+Rid. (@ 200g+250g+300g+250g/100 L water)	4.3	4.2	3.8	4.2	4.1 BCD
T_{12}	No fungicide (Check)	3.8	3.8	3.8	3.9	3.8 D
	Mean	4.2	4.2	4.2	4.2	4.2

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another.

Table 3. Synergy of fungicides in controlling downy mildew of onion during 1997-98 (Replicated data of bulb number)

Treatment		Replications				Mean
		1	2	3	4	
T_1	Antracol (@ 200g/100 L water)	40	40	23	38	35.3 ABC[1]
T_2	Copper Oxychloride (@ 250g/100 L water)	30	40	23	14	26.8 CD
T_3	Dithane M-45 (@ 300g/100 L water)	28	25	24	28	26.3 CD
T_4	Ridomil (@ 250g/100 L water)	30	37	42	38	36.8 AB
T_5	Antracol + Copper Oxychloride (@ 200g+250g/100 L water)	35	36	29	24	31.0 ABCD
T_6	Antracol + Dithane M-45 (@ 200g+300g/100 L water)	19	24	37	20	25.0 D
T_7	Antracol + Ridomil (@ 200g+250g/100 L water)	37	40	42	42	40.3 A
T_8	Copper Oxy. + Dithane M-45 (@ 250g+300g/100 L water)	27	32	26	27	28.0 BCD
T_9	Copper Oxychloride + Ridomil (@ 250g+250g/100 L water)	28	29	43	28	32.0 ABCD
T_{10}	Dithane + Ridomil (@ 300g+250g/100 L water)	28	26	25	22	25.3 D
T_{11}	Antra.+Copper Oxy.+Dith.+Rid. (@ 200g+250g+300g+250g/100 L water)	27	20	20	44	27.8 BC
T_{12}	No fungicide (Check)	20	24	23	22	22.3 D
	Mean	29.1	31.1	29.8	28.9	29.7

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another.

Table 4. **Synergy of fungicides in controlling downy mildew of onion during 1997-98 (Replicated data on bulb yield)**

	Treatment	Replications				Mean
		1	2	3	4	
T_1	Antracol (@ 200g/100 L water)	15.0	15.3	17.0	17.5	16.2 ABC[1]
T_2	Copper Oxychloride (@ 250g/100 L water)	18.0	16.0	14.0	14.5	15.6 BCE
T_3	Dithane M-45 (@ 300g/100 L water)	16.5	14.5	17.5	14.0	15.6 BC
T_4	Ridomil (@ 250g/100 L water)	17.0	17.5	16.0	16.5	16.8 AB
T_5	Antracol + Copper Oxychloride (@ 200g+250g/100 L water)	17.0	15.0	15.5	14.0	15.4 BC
T_6	Antracol + Dithane M-45 (@ 200g+300g/100 L water)	14.5	14.9	16.3	16.2	15.5 BC
T_7	Antracol + Ridomil (@ 200g+250g/100 L water)	18.0	18.0	18.0	17.5	17.9 A
T_8	Copper Oxy. + Dithane M-45 (@ 250g+300g/100 L water)	14.5	15.2	18.0	16.1	15.9 BC
T_9	Copper Oxychloride + Ridomil (@ 250g+250g/100 L water)	15.0	16.2	14.5	17.5	15.8 BC
T_{10}	Dithane + Ridomil (@ 300g+250g/100 L water)	16.8	15.5	15.0	18.0	16.3 ABC
T_{11}	Antra.+Copper Oxy.+Dith.+Rid. (@ 200g+250g+300g+250g/100 L water)	16.5	14.5	14.8	18.0	15.9 BC
T_{12}	No fungicide (Check)	15.0	14.5	15.0	14.0	14.6 C
	Mean	16.2	15.6	15.9	16.2	15.9

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another.

APPENDIX-II

Table 1. **Effect of host management on onion downy mildew control during 1997-98 (Mean Disease Severity).**

Treatment	Disease Severity Scoring (%)				Mean	Mean AUDPC calculated
	7.4.98	17.4.98	27.4.98	7.5.98		
T_1 ($I_1F_1P_1$)	8.3 AB*	16.7	40.0 AB	66.7 AB	32.9	314.0 CDE[1]
T_2 ($I_1F_1P_2$)	8.3 AB	16.7	40.0 AB	66.7 AB	32.9	314.0 CDE
T_3 ($I_1F_1P_3$)	10.0 AB	20.0	50.0 AB	75.0 A	38.8	375.0 BC
T_4 ($I_1F_2P_1$)	6.7 B	13.3	30.0 B	50.0 CD	25.0	238.8 FG
T_5 ($I_1F_2P_2$)	13.3 A	30.0	58.3 A	80.0 A	45.4	449.8 CDE
T_6 ($I_1F_2P_3$)	13.3 A	30.0	58.3 A	80.0 A	45.4	449.8 BC
T_7 ($I_1F_3P_1$)	6.7 B	13.3	30.0 B	50.0 CD	25.0	238.8 DEF
T_8 ($I_1F_3P_2$)	8.3 AB	16.7	40.0 AB	66.7 AB	32.9	314.0 BC
T_9 ($I_1F_3P_3$)	10.0 AB	20.0	50.0 AB	75.0 A	38.8	375.0 A
T_{10} ($I_2F_1P_1$)	8.3 AB	16.7	40.0 AB	58.3 BC	30.8	300.0 CDE
T_{11} ($I_2F_1P_2$)	10.0 AB	20.0	50.0 AB	75.0 A	38.8	375.0 BC
T_{12} ($I_2F_1P_3$)	13.3 A	30.0	58.3 A	80.0 A	45.5	449.8 AB
T_{13} ($I_2F_2P_1$)	8.3 AB	16.7	40.0 AB	66.7 AB	32.9	314.0 EFG
T_{14} ($I_2F_2P_2$)	10.0 AB	20.0	50.0 AB	75.0 A	38.8	375.0 CDE
T_{15} ($I_2F_2P_3$)	13.3 A	30.0	50.0 AB	75.0 A	42.1	413.8 BC
T_{16} ($I_2F_3P_1$)	6.7 B	13.3	30.0 B	58.3 BC	27.1	252.7 CDE
T_{17} ($I_2F_3P_2$)	8.3 AB	16.7	40.0 AB	66.7 AB	32.9	314.0 BC
T_{18} ($I_2F_3P_3$)	10.0 AB	20.0	50.0 AB	75.0 A	38.8	375.0 A
T_{19} ($I_3F_1P_1$)	8.3 AB	16.7	40.0 AB	66.7 AB	32.9	314.0 G

(Table 1 cont.)

Table 1(cont.) **Effect of host management on onion downy mildew control during 1997-98 (Mean Disease Severity).**

T_{20} ($I_3F_1P_2$)	10.0 AB	20.0	50.0 AB	75.0 A	38.8	375.0 BC
T_{21} ($I_3F_1P_3$)	13.3 A	30.0	58.3 A	80.0 A	45.5	449.8 A
T_{22} ($I_3F_2P_1$)	8.3 AB	13.3	30.0 B	40.0 D	22.9	224.8 CD
T_{23} ($I_3F_2P_2$)	10.0 AB	20.0	50.0 AB	75.0 A	38.8	375.0 BC
T_{24} ($I_3F_2P_3$)	13.3 A	30.0	58.3 A	80.0 A	45.5	449.8 A
T_{25} ($I_3F_3P_1$)	8.3 AB	16.7	40.0 AB	66.7 AB	32.9	347.3 CD
T_{26} ($I_3F_3P_2$)	10.0 AB	20.0	50.0 AB	75.0 A	38.8	375.0 BC
T_{27} ($I_3F_3P_3$)	13.3 A	30.0	58.3 A	80.0 A	45.5	449.8 A
Mean	9.9	20.6	45.9	69.6	36.5	355.5
LSD value	6.2	--	21.9	14.9	-	63.7
CV (%)	37.9	49.7	28.8	13.0	-	10.8

I_1 = six irrigations/season; I_2 = seven irrigations/season and I_3 = eight irrigations/season

F_1 = NPK 90:60:30 kg/ha; F_2 = NPK 120:90:60 kg/ha and F_3 = NPK 150:120:90 kg/ha

P_1 = 0.5 million plants/ha; P_2 = 0.75 million plants/ha and P_3 = 1.0 million plants/ha

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 2. **Effect of host management on onion downy mildew control during 1997-98 (Replicated Data of bulb size).**

Treatment	Replications			Mean
	1	2	3	
T_1 ($I_1F_1P_1$)	5.0	3.8	3.8	4.2 C-J[1]
T_2 ($I_1F_1P_2$)	4.4	3.8	4.8	4.3 B-I
T_3 ($I_1F_1P_3$)	4.2	4.5	4.7	4.5 B-G
T_4 ($I_1F_2P_1$)	3.5	4.0	3.9	3.8 IJ
T_5 ($I_1F_2P_2$)	4.2	4.2	3.9	4.1 E-J
T_6 ($I_1F_2P_3$)	4.4	4.0	4.2	4.2 C-J
T_7 ($I_1F_3P_1$)	4.6	4.5	4.3	4.5 B-G
T_8 ($I_1F_3P_2$)	4.3	4.8	4.7	4.6 B-E
T_9 ($I_1F_3P_3$)	4.4	4.5	4.6	4.5 B-F
T_{10} ($I_2F_1P_1$)	3.5	4.2	4.1	3.9 G-J
T_{11} ($I_2F_1P_2$)	3.6	4.0	4.3	3.9 F-J
T_{12} ($I_2F_1P_3$)	3.7	4.3	3.9	3.9 F-G
T_{13} ($I_2F_2P_1$)	4.3	4.3	4.2	4.3 B-J
T_{14} ($I_2F_2P_2$)	3.9	4.1	3.7	3.9 HIJ
T_{15} ($I_2F_2P_3$)	3.4	3.8	4.1	3.8 J
T_{16} ($I_2F_3P_1$)	4.2	3.9	4.5	4.2 C-J
T_{17} ($I_2F_3P_2$)	3.8	4.7	4.8	4.4 B-H
T_{18} ($I_2F_3P_3$)	3.8	4.0	4.4	4.1 E-J
T_{19} ($I_3F_1P_1$)	4.7	4.4	5.0	4.7 BCD
T_{20} ($I_3F_1P_2$)	5.2	4.4	4.0	4.5 B-E
T_{21} ($I_3F_1P_3$)	4.0	4.6	4.3	4.3 B-J

(Table 2 cont.)

Table 2(cont.) Effect of host management on onion downy mildew control during 1997-98 (Replicated Data of bulb size)

T_{22} $(I_3F_2P_1)$	5.4	5.3	5.3	5.3 A
T_{23} $(I_3F_2P_2)$	4.5	4.1	4.0	4.2 D-J
T_{24} $(I_3F_2P_3)$	4.3	4.2	4.0	4.2 B-J
T_{25} $(I_3F_3P_1)$	4.5	5.0	4.8	4.8 B
T_{26} $(I_3F_3P_2)$	5.3	4.7	4.0	4.7 BCD
T_{27} $(I_3F_3P_3)$	5.0	4.7	4.5	4.7 BC
Mean	4.3	4.3	4.3	4.3

I_1 = six irrigations/season; I_2 = seven irrigations/season and I_3 = eight irrigations/season
F_1 = NPK 90:60:30 kg/ha; F_2 = NPK 120:90:60 kg/ha and F_3 = NPK 150:120:90 kg/ha
P_1 = 0.5 million plants/ha; P_2 = 0.75 million plants/ha and P_3 = 1.0 million plants/ha
[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 3. **Effect of host management on onion downy mildew control during 1997-98 (Replicated Data of bulb number)**

Treatment		Replications			Mean
		1	2	3	
T_1	$(I_1F_1P_1)$	22	11	16	16.3 M[1]
T_2	$(I_1F_1P_2)$	24	15	23	20.7 KL
T_3	$(I_1F_1P_3)$	25	20	28	24.3 H-K
T_4	$(I_1F_2P_1)$	32	24	24	26.7 E-J
T_5	$(I_1F_2P_2)$	32	26	27	28.3 D-H
T_6	$(I_1F_2P_3)$	36	30	32	32.7 BC
T_7	$(I_1F_3P_1)$	22	21	12	18.3 LM
T_8	$(I_1F_3P_2)$	23	25	21	23.0 JK
T_9	$(I_1F_3P_3)$	26	27	22	25.0 G-J
T_{10}	$(I_2F_1P_1)$	27	31	17	25.0 G-J
T_{11}	$(I_2F_1P_2)$	31	30	23	28.0 D-I
T_{12}	$(I_2F_1P_3)$	37	34	28	23.0 ABC
T_{13}	$(I_2F_2P_1)$	29	23	20	24.0 IJK
T_{14}	$(I_2F_2P_2)$	33	26	19	26.0 E-J
T_{15}	$(I_2F_2P_3)$	34	28	33	31.7 BCD
T_{16}	$(I_2F_3P_1)$	31	30	21	27.3 E-I
T_{17}	$(I_2F_3P_2)$	38	29	23	30.0 CDE
T_{18}	$(I_2F_3P_3)$	39	35	24	32.7 BC
T_{19}	$(I_3F_1P_1)$	33	28	27	29.3 C-F
T_{20}	$(I_3F_1P_2)$	33	36	27	32.0 BCD
T_{21}	$(I_3F_1P_3)$	35	41	28	34.7 AB
T_{22}	$(I_3F_2P_1)$	28	29	23	26.7 E-J

Table 3 cont.)

Table 3(cont.) **Effect of host management on onion downy mildew control during 1997-98 (Replicated Data of Bulb Number)**

T_{23}	$(I_3F_2P_2)$	29	29	29	29.0 C-G
T_{24}	$(I_3F_2P_3)$	35	38	38	37.0 A
T_{25}	$(I_3F_3P_1)$	30	21	25	25.3 F-J
T_{26}	$(I_3F_3P_2)$	32	27	30	29.7 CDE
T_{27}	$(I_3F_3P_3)$	35	37	32	34.7 AB
	Mean	30.8	27.8	24.9	27.8

I_1 = six irrigations/season; I_2 = seven irrigations/season and I_3 = eight irrigations/season
F_1 = NPK 90:60:30 kg/ha; F_2 = NPK 120:90:60 kg/ha and F_3 = NPK 150:120:90 kg/ha
P_1 = 0.5 million plants/ha; P_2 = 0.75 million plants/ha and P_3 = 1.0 million plants/ha
[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 4. **Effect of host management on onion downy mildew control during 1997-98 (Replicated Data of bulb yield).**

Treatment		Replications			Mean
		1	2	3	
T_1	$(I_1F_1P_1)$	8.0	2.5	15.0	8.5 B[1]
T_2	$(I_1F_1P_2)$	5.0	2.5	16.5	8.0 B
T_3	$(I_1F_1P_3)$	7.0	7.5	16.0	10.2 AB
T_4	$(I_1F_2P_1)$	12.5	6.0	15.0	11.2 AB
T_5	$(I_1F_2P_2)$	7.5	5.0	14.0	8.8 B
T_6	$(I_1F_2P_3)$	7.5	4.0	16.8	9.4 B
T_7	$(I_1F_3P_1)$	7.0	7.0	15.0	9.7 B
T_8	$(I_1F_3P_2)$	6.0	7.0	17.8	10.3 AB
T_9	$(I_1F_3P_3)$	15.0	7.0	7.5	9.8 AB
T_{10}	$(I_2F_1P_1)$	4.5	7.0	4.5	5.3 B
T_{11}	$(I_2F_1P_2)$	6.0	15.0	5.6	8.9 B
T_{12}	$(I_2F_1P_3)$	15.0	17.5	5.5	12.7 AB
T_{13}	$(I_2F_2P_1)$	7.0	14.0	15.0	12.0 AB
T_{14}	$(I_2F_2P_2)$	15.0	5.0	14.0	11.3 AB
T_{15}	$(I_2F_2P_3)$	6.0	15.0	16.5	12.5 AB
T_{16}	$(I_2F_3P_1)$	7.5	16.0	5.0	9.5 B
T_{17}	$(I_2F_3P_2)$	6.0	7.0	15.8	9.6 B
T_{18}	$(I_2F_3P_3)$	7.0	5.0	15.5	9.2 B
T_{19}	$(I_3F_1P_1)$	7.5	7.0	17.5	10.7 AB
T_{20}	$(I_3F_1P_2)$	8.0	6.0	18.0	10.0 AB
T_{21}	$(I_3F_1P_3)$	7.0	18.0	6.0	10.3 AB

(Table 4 cont.)

Table 4(cont.) **Effect of host management on onion downy mildew control during 1997-98 (Replicated Data of Bulb Yield)**

T_{22}	$(I_3F_2P_1)$	17.5	17.5	19.0	18.0 A
T_{23}	$(I_3F_2P_2)$	7.0	15.0	17.0	13.0 AB
T_{24}	$(I_3F_2P_3)$	16.	17.5	7.0	13.5 AB
T_{25}	$(I_3F_3P_1)$	7.5	7.0	17.0	10.5 AB
T_{26}	$(I_3F_3P_2)$	15.0	17.5	7.5	13.3 AB
T_{27}	$(I_3F_3P_3)$	5.0	17.5	5.0	9.2 B
	Mean	8.9	10.1	12.7	10.6

I_1 = six irrigations/season; I_2 = seven irrigations/season and I_3 = eight irrigations/season
F_1 = NPK 90:60:30 kg/ha; F_2 = NPK 120:90:60 kg/ha and F_3 = NPK 150:120:90 kg/ha
P_1 = 0.5 million plants/ha; P_2 = 0.75 million plants/ha and P_3 = 1.0 million plants/ha
[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

APPENDIX-III

Table 1. **Influence of intercropping on downy mildew control in onion during 1997-98 (Mean Disease Severity).**

Treatment	Disease Severity Scoring (%)				Mean	Mean AUDPC calculated
	14.4.98	24.4.98	04.5.98	14.5.98		
T_1 (Onion)	6.3	12.5	27.5	56.3	25.7	237.7 B[1]
T_2 (Onion+Garlic)	7.5	15.0	35.0	62.5	30.0	283.3 A
T_3 (Onion+Pea)	6.3	12.5	27.5	56.3	25.7	237.7 B
T_4 (Onion+Wheat)	6.3	12.5	35.0	62.5	29.1	273.0 A
T_5 (Onion+Pea+Garlic)	6.3	12.5	35.0	62.5	29.1	273.0 A
T_6 (Onion+Pea+Wheat)	6.3	12.5	27.5	56.3	25.7	237.7 B
T_7 (Onion+Garlic+Wheat)	6.3	12.5	27.5	56.3	25.7	237.7 B
T_8 (Onion+Pea+Garlic+Wheat)	7.5	15.0	35.0	62.5	30.0	283.3 A
Mean	6.6	13.1	31.3	59.4	27.6	257.9
LSD value	--	--	--	--	--	28.6
CV (%)	37.6	37.6	51.3	22.5	--	6.3

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another.

Table 2. **Influence of intercropping on downy mildew control in onion during 1997-98 (Replicated Data on bulb size).**

Treatment	Replications				Mean
	1	2	3	4	
T_1 (Onion)	4.6	4.9	4.5	5.1	4.8 A[1]
T_2 (Onion+Garlic)	3.9	4.0	3.7	4.0	3.9 BC
T_3 (Onion+Pea)	4.4	4.3	4.6	5.4	4.7 A
T_4 (Onion+Wheat)	3.5	3.5	4.0	3.8	3.7 C
T_5 (Onion+Pea+Garlic)	3.9	3.6	4.0	4.8	4.1 BC
T_6 (Onion+Pea+Wheat)	4.0	3.6	3.6	3.9	3.8 BC
T_7 (Onion+Garlic+Wheat)	4.1	4.3	3.5	4.0	3.9 BC
T_8 (Onion+Pea+Garlic+Wheat)	4.0	4.1	4.1	4.3	4.1 B
Mean	4.1	4.0	4.0	4.4	4.1

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 3. **Influence of intercropping on downy mildew control in onion during 1997-98 (Replicated Data of bulb number).**

Treatment	Replications				Mean
	1	2	3	4	
T_1 (Onion)	35	31	20	30	29.0 A[1]
T_2 (Onion+Garlic)	21	22	15	19	19.3 B
T_3 (Onion+Pea)	16	19	23	22	20.0 B
T_4 (Onion+Wheat)	9	10	6	7	8.0 D
T_5 (Onion+Pea+Garlic)	10	21	15	14	15.0 BC
T_6 (Onion+Pea+Wheat)	10	14	12	16	13.0 CD
T_7 (Onion+Garlic+Wheat)	21	18	14	21	18.5 B
T_8 (Onion+Pea+Garlic+Wheat)	17	21	10	15	15.5 BC
Mean	17.4	19.5	14.4	18.0	17.3

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 4. **Influence of intercropping on downy mildew control in onion during 1997-98 (Replicated Data on bulb yield).**

Treatment	Replications				Mean
	1	2	3	4	
T_1 (Onion)	17.0	18.5	16.0	15.1	16.7 A[1]
T_2 (Onion+Garlic)	15.0	17.4	2.5	2.4	9.3 AB
T_3 (Onion+Pea)	5.0	7.0	18.0	7.5	9.4 AB
T_4 (Onion+Wheat)	2.2	2.0	0.5	1.0	1.4 B
T_5 (Onion+Pea+Garlic)	2.5	14.8	2.7	3.0	5.8 B
T_6 (Onion+Pea+Wheat)	13.5	2.5	3.0	15.0	8.5 AB
T_7 (Onion+Garlic+Wheat)	15.0	2.8	2.5	5.0	6.3 B
T_8 (Onion+Pea+Garlic+Wheat)	4.0	16.0	2.5	6.5	7.3 B
Mean					8.1

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 5. **Influence of intercropping on downy mildew control in onion during 1997-98 (Replicated Data of pea yield).**

Treatment	Replications				Mean
	1	2	3	4	
T_1 (Onion)	0	0	0	0	0.0 B[1]
T_2 (Onion+Garlic)	0	0	0	0	0.0 B
T_3 (Onion+Pea)	6.0	6.1	6.9	5.0	6.0 A
T_4 (Onion+Wheat)	0	0	0	0	0.0 B
T_5 (Onion+Pea+Garlic)	5.3	6.9	6.9	8.1	6.8 A
T_6 (Onion+Pea+Wheat)	6.1	6.7	8.1	4.8	6.4 A
T_7 (Onion+Garlic+Wheat)	0	0	0	0	0.0 B
T_8 (Onion+Pea+Garlic+Wheat)	6.8	6.3	10.1	4.7	6.9 A
Mean	3.0	3.3	4.0	2.8	3.3

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 6. **Influence of intercropping on downy mildew control in onion during 1997-98 (Replicated Data of garlic yield)**

Treatment	Replications				Mean
	1	2	3	4	
T_1 (Onion)	0	0	0	0	0.0 C[1]
T_2 (Onion+Garlic)	5.2	6.9	5.7	5.4	5.8 A
T_3 (Onion+Pea)	0	0	0	0	0.0 C
T_4 (Onion+Wheat)	0	0	0	0	0.0 C
T_5 (Onion+Pea+Garlic)	6.1	6.3	7.5	5.0	6.2 A
T_6 (Onion+Pea+Wheat)	0	0	0	0	0.0 C
T_7 (Onion+Garlic+Wheat)	7.0	6.7	5.6	6.3	6.4 A
T_8 (Onion+Pea+Garlic+Wheat)	2.7	3.9	3.3	3.8	3.4 B
Mean	2.6	2.9	2.8	2.6	2.7

[1] Figures followed by different letters are significantly different ($P < 0.05$) from one another

Table 7. **Influence of intercropping on downy mildew control in onion during 1997-98 (Replicated Data of wheat yield).**

Treatment	Replications				Mean
	1	2	3	4	
T_1 (Onion)	0	0	0	0	0.0 C[1]
T_2 (Onion+ Garlic)	0	0	0	0	0.0 C
T_3 (Onion+ Pea)	0	0	0	0	0.0 C
T_4 (Onion+ Wheat)	3.8	4.3	4.8	4.9	4.5 AB
T_5 (Onion+ Pea+ Garlic)	0	0	0	0	0.0 C
T_6 (Onion+ Pea+ Wheat)	5.8	4.2	5.5	4.4	4.9 A
T_7 (Onion+ Garlic+ Wheat)	3.9	4.4	4.6	4.4	4.3 B
T_8 (Onion+ Pea+ Garlic+ Wheat)	4.6	4.6	4.6	4.1	4.5 AB
Mean	2.3	2.2	2.4	2.2	2.3

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

APPENDIX-IV

Table 1. Relative efficacy of weed control methods in controlling onion downy mildew during 1997-98 (Mean disease severity).

Treatment		Disease Severity Scoring (%)				Mean	Mean AUPDC calculated
		14.4.98	24.4.98	04.5.98	14.5.98		
T_1	2.4-D (@ 3.5g/L + weeding)	15.0 BC	25.0 CD	48.8 BC	72.5 B	40.3	391.8 D[1]
T_2	2.4-d (@ 3.5g/L + no weeding)	17.5 BC	31.3 BC	59.4 AB	80.6 AB	47.2	465.8 BC
T_3	2.4-D (@ 4.5g/L + weeding	16.3 BC	27.5 BCD	56.3 AB	75.6 AB	43.9	432.5 CD
T_4	2.4-D (@ 4.5g/L + no weeding)	22.5 B	38.8 AB	65.6 A	80.6 AB	51.9	519.8 AB
T_5	2.4-D (@ 5.5g/L + weeding)	22.5 B	35.0 ABC	62.5 A	80.6 AB	50.2	496.8 BC
T_6	2.4-D(@ 5.5g/ L + no weeding)	35.0 A	46.3 A	68.8 A	82.5 A	58.2	579.5 A
T_7	No herbicide + weeding (Check 1)	12.5 C	16.3 D	38.8 C	53.1 C	30.2	293.0 E
T_8	No herbicide + no weeding (Double zero - Check 2)	15.0 BC	31.3 BC	62.5 A	82.5 A	47.8	475.2 BC
	Mean	19.5	31.4	57.8	76.0	46.2	456.8
	LSD value	8.0	12.5	12.7	9.5	--	68.2
	CV (%)	40.1	38.9	21.4	12.2	--	7.9

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 2. Relative efficacy of weed control methods in controlling onion downy mildew during 1997-98 (Replicated data of bulb dize).

Treatment		Replications								Mean
		1	2	3	4	5	6	7	8	
T_1	2.4-D (@ 3.5g/L + weeding)	3.5	3.3	3.0	3.0	3.5	3.0	3.5	2.5	3.2 C[1]
T_2	2.4-d (@ 3.5g/L + no weeding)	3.0	2.7	2.3	2.5	2.7	2.7	2.5	2.3	2.6 D
T_3	2.4-D (@ 4.5g/L + weeding	4.9	2.7	2.8	2.8	3.2	2.3	2.5	2.5	2.9 CD
T_4	2.4-D (@ 4.5g/L + no weeding)	2.8	2.8	2.7	2.3	2.5	2.3	2.5	3.0	2.6 D
T_5	2.4-D (@ 5.5g/L + weeding)	3.7	2.8	2.3	2.5	2.7	2.3	2.2	2.5	2.6 D
T_6	2.4-D(@ 5.5g/ L + no weeding)	4.8	2.3	2.3	2.2	2.2	2.5	2.3	2.3	2.6 D
T_7	No herbicide + weeding (Check 1)	4.5	4.8	4.6	4.5	4.6	4.8	4.5	4.8	4.6 A
T_8	No herbicide + no weeding (Double zero - Check 2)	3.8	3.4	4.0	3.4	4.2	3.6	3.4	3.5	3.7 B
	Mean	3.9	3.1	3.0	2.9	3.2	2.9	2.9	2.9	3.1

[1] Figures followed by different letters are significantly different ($P < 0.05$) from one another

Table 3. Relative efficacy of weed control methods in controlling onion downy mildew during 1997-98 (Replicated data of bulb number).

Treatment		Replications								Mean
		1	2	3	4	5	6	7	8	
T_1	(2.4-D @ 3.5g/L + weeding)	16	15	10	12	11	9	8	9	11.3 C[1]
T_2	(2.4-d @ 3.5g/L + no weeding)	15	14	9	11	10	9	7	9	10.5 D
T_3	(2.4-D @ @ 4.5g/L + weeding	14	11	8	10	10	8	7	8	9.5 E
T_4	(2.4-D @ 4.5g/L + no weeding)	13	10	8	9	9	8	7	8	9.0 EF
T_5	(2.4-D @ 5.5g/L + weeding)	12	10	7	9	9	8	7	7	8.6 FG
T_6	(2.4-D @ 5.5g/ L + no weeding)	10	9	7	8	8	8	7	7	8.0 G
T_7	(No herbicide + weeding)	25	29	21	38	28	29	29	27	28.3 A
T_8	(No herbicide + no weeding)	23	28	17	38	26	26	25	24	25.9 B
	Mean	16	15.8	10.9	16.9	13.9	13.1	12.1	12.4	13.9

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 4. Relative efficacy of weed control methods in controlling onion downy mildew during 1997-98 (Replicated data of bulb yield).

Treatment		Replications								Mean
		1	2	3	4	5	6	7	8	
T_1	2.4-D (@ 3.5g/L + weeding)	4.0	3.5	3.5	3.0	2.5	2.0	2.5	2.5	2.9 C[1]
T_2	2.4-d (@ 3.5g/L + no weeding)	3.5	3.4	3.4	3.0	2.4	2.0	2.4	2.2	2.8 C
T_3	2.4-D (@ 4.5g/L + weeding	3.4	3.2	3.0	2.9	2.4	2.0	2.4	2.4	2.7 C
T_4	2.4-D (@ 4.5g/L + no weeding)	3.0	3.1	2.8	2.5	2.5	2.0	2.1	2.3	2.5 C
T_5	2.4-D (@ 5.5g/L + weeding)	3.2	3.1	3.0	2.8	2.4	2.0	2.2	2.2	2.6 C
T_6	2.4-D(@ 5.5g/ L + no weeding)	3.0	3.0	2.8	2.5	2.4	2.0	2.1	2.1	2.5 C
T_7	No herbicide + weeding (Check 1)	18.2	14.4	15.4	17.4	14.0	13.6	13.8	15.1	15.2 A
T_8	No herbicide + no weeding (Double zero - Check 2)	12.7	13.5	11.0	6.5	4.9	5.0	12.7	14.5	10.1 B
	Mean	6.4	5.9	5.6	5.1	4.2	3.8	5.0	5.4	5.2

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

APPENDIX-V

Table 1. Synergy of fungicides in controlling downy mildew of onion during 1998-99 (Mean disease severity).

	Treatment	Disease Severity Scoring (%)				Mean	Mean AUDPC calculated
		26.03.99	05.04.99	15.04.99	25.04.99		
T_1	Antracol (@ 200g/100 L water)	12.5	35.0 ABC	48.8 BC	56.3 AB	38.2	394.0 BC[1]
T_2	Copper Oxychloride (@ 250g/100 L water)	15.0	42.5 AB	56.3 AB	62.5 A	44.1	458.5 AB
T_3	Dithane M-45 (@ 300g/100 L water)	15.0	35.0 ABC	56.3 AB	62.5 A	42.2	433.5 ABC
T_4	Ridomil (@ 250g/100 L water)	15.0	20.0 C	17.5 DE	15.0 D	16.9	175.1 DE
T_5	Antracol + Copper Oxychloride (@ 200g+250g/100 L water)	17.5	35.0 ABC	56.3 AB	62.5 A	42.8	436.9 ABC
T_6	Antracol + Dithane M-45 (@ 200g+300g/100 L water)	15.0	42.5 AB	56.3 AB	62.5 A	44.1	458.5 AB
T_7	Antracol + Ridomil (@ 200g+250g/100 L water)	15.0	17.5 C	17.5 DE	15.0 D	16.3	166.7 DE
T_8	Copper Oxy. + Dithane M-45 (@ 250g+300g/100 L water)	17.5	42.5 AB	56.3 AB	62.5 A	44.7	462.7 AB
T_9	Copper Oxychloride + Ridomil (@ 250g+250g/100 L water)	15.0	27.5 BC	35.0 CD	41.3 BC	29.7	302.2 CD
T_{10}	Dithane + Ridomil (@ 300g+250g/100 L water)	15.0	17.5 C	15.0 E	10.0 D	14.4	154.2 E
T_{11}	Antra.+Copper Oxy.+Dith.+Rid. (@ 200g+250g+300g+250g/100 L water)	15.0	27.5 BC	27.5 DE	25.0 CD	23.8	250.0 DE
T_{12}	No fungicide (Check)	17.5	50.0 A	68.8 A	75.0 A	52.8	550.2 A
	Mean	15.4	32.9	42.8	46.0	34.3	353.5
	LSD value	-	18.9	18.7	19.5	-	136.6
	CV (%)	36.7	40.0	30.3	29.5	-	136.6

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 2. Synergy of fungicides in controlling downy mildew of onion during 1998-99 (Replicated data of bulb size).

Treatment		Replications				Mean
		1	2	3	4	
T_1	Antracol (@ 200g/100 L water)	4.4	4.6	4.5	4.8	4.6 CDE[1]
T_2	Copper Oxychloride (@ 250g/100 L water)	4.5	4.6	4.5	4.5	4.5 DEF
T_3	Dithane M-45 (@ 300g/100 L water)	4.8	4.9	4.5	5.1	4.8 BCD
T_4	Ridomil (@ 250g/100 L water)	5.6	5.1	5.0	4.6	5.1 B
T_5	Antracol + Copper Oxychloride (@ 200g+250g/100 L water)	4.6	3.9	4.0	4.6	4.3 EFG
T_6	Antracol + Dithane M-45 (@ 200g+300g/100 L water)	4.5	4.5	4.3	4.4	4.4 EF
T_7	Antracol + Ridomil (@ 200g+250g/100 L water)	4.9	5.1	5.0	4.7	4.9 BC
T_8	Copper Oxy. + Dithane M-45 (@ 250g+300g/100 L water)	4.1	4.1	4.1	4.3	4.2 FG
T_9	Copper Oxychloride + Ridomil (@ 250g+250g/100 L water)	4.3	3.5	4.5	4.3	4.2 FG
T_{10}	Dithane + Ridomil (@ 300g+250g/100 L water)	6.3	5.6	5.9	5.8	5.9 A
T_{11}	Antra.+Copper Oxy.+Dith.+Rid. (@ 200g+250g+300g+250g/100 L water)	4.9	4.4	4.1	4.5	4.5 DEF
T_{12}	No fungicide (Check)	4.1	3.6	3.8	4.2	3.9 G
	Mean	4.8	4.9	4.5	4.7	4.6

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 3. Synergy of fungicides in controlling downy mildew of onion during 1998-99 (Replicated data of bulb number)

	Treatment	Replications				Mean
		1	2	3	4	
T_1	(Antracol @ 200g/100 l H_2O)	37	35	37	28	34.3 BCDE[1]
T_2	(Copper Oxychloride @ 250g/100 l H_2O)	28	29	27	28	29.0 E
T_3	(Dithane M-45 @ 300g/100 l H_2O)	39	25	39	38	35.3 ABCD
T_4	(Ridomil @ 250g/100 l H_2O)	33	33	38	45	37.3 ABC
T_5	(Antracol+Copper Oxychloride 200g+250g/100 L H_2O)	34	40	26	32	33.0 BCDE
T_6	(Antracol + Dithane M-45 200g+300g/100 L H_2O)	29	24	34	35	30.5 CDE
T_7	(Antracol + Ridomil 200g+250g/100 L H_2O)	39	39	34	38	37.5 AB
T_8	(Copper Oxy. + Dithane M-45 250g+300g/100 L H_2O)	37	28	36	27	32.0 BCDE
T_9	(Copper Oxychloride + Ridomil 250g+250g/100 L H_2O)	40	38	25	38	35.3 ABCD
T_{10}	(Dithane + Ridomil 300g+250g/100 L H_2O)	44	34	42	45	41.3 A
T_{11}	(Antra.+Copper Oxy.+Dith.+Rid. 200g+250g+300g+250g/100 L H_2O)	35	31	38	30	33.5 BCDE
T_{12}	(No fungicide; Check)	27	29	29	30	28.8 DE
	Mean	35.2	32.1	33.8	34.5	33.9

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 4. Synergy of fungicides in controlling downy mildew of onion during 1998-99 (Replicated data on bulb yield)

	Treatment	Replications				Mean
		1	2	3	4	
T_1	(Antracol @ 200g/100 l H_2O)	15.2	10.3	14.0	9.0	12.1 DE[1]
T_2	(Copper Oxychloride @ 250g/100 l H_2O)	15.0	10.9	13.0	14.0	13.2 CDE
T_3	(Dithane M-45 @ 300g/100 l H_2O)	15.5	15.0	14.5	14.0	14.8 BCDE
T_4	(Ridomil @ 250g/100 l H_2O)	15.8	15.6	20.0	19.8	17.8 B
T_5	(Antracol+Copper Oxychloride 200g+250g/100 L H_2O)	10.0	15.0	18.0	10.2	13.3 CDE
T_6	(Antracol + Dithane M-45 200g+300g/100 L H_2O)	14.0	14.5	11.0	14.5	13.5 CDE
T_7	(Antracol + Ridomil 200g+250g/100 L H_2O)	10.5	19.5	15.5	23.5	17.3 BC
T_8	(Copper Oxy. + Dithane M-45 250g+300g/100 L H_2O)	10.0	12.0	12.0	10.3	11.1 D
T_9	(Copper Oxychloride + Ridomil 250g+250g/100 L H_2O)	15.5	16.0	14.0	15.2	15.2 BCD
T_{10}	(Dithane + Ridomil 300g+250g/100 L H_2O)	20.0	21.0	21.0	25.8	21.9 A
T_{11}	(Antra.+Copper Oxy.+Dith.+Rid. 200g+250g+300g+250g/100 L H_2O)	15.0	21.0	21.0	15.2	18.1 AB
T_{12}	(No fungicide; Check)	14.0	9.0	10.2	10.0	10.8 E
	Mean	14.2	14.9	15.4	15.1	14.9

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

APPENDIX-VI

Table 1. Effect of host management on onion downy mildew control during 1998-99 (Mean disease severity).

Treatment	Disease Severity Scoring (%)				Mean	Mean AUDPC calculated
	(21.03.99)	(05.04.99)	(15.04.99)	(25.04.99)		
T_1 ($I_1F_1P_1$)	13.3 BCD	30.0 BC	50.0 C	58.3 C	37.9	386.1 F[1]
T_2 ($I_1F_1P_2$)	11.7 CD	30.0 BC	58.3 BC	66.7 BC	41.7	425.1 E
T_3 ($I_1F_1P_3$)	16.7 ABCD	40.0 AB	66.7 ABC	75.0 AB	49.6	508.6 D
T_4 ($I_1F_2P_1$)	13.3 BCD	30.0 BC	58.3 BC	66.7 BC	42.1	427.7 E
T_5 ($I_1F_2P_2$)	16.7 ABCD	40.0 AB	66.7 ABC	75.0 AB	49.6	508.6 D
T_6 ($I_1F_2P_3$)	20.0 ABCD	50.0 AB	75.0 AB	80.0 AB	56.3	583.3 BC
T_7 ($I_1F_3P_1$)	13.3 BCD	30.0 BC	58.3 BC	66.7 BC	42.1	427.7 E
T_8 ($I_1F_3P_2$)	16.7 ABCD	40.0 AB	66.7 ABC	75.0 AB	49.6	508.6 D
T_9 ($I_1F_3P_3$)	20.0 ABCD	50.0 AB	75.0 AB	80.0 AB	56.3	583.3 BC
T_{10} ($I_2F_1P_1$)	13.3 BCD	30.0 BC	58.3 BC	66.7 BC	42.1	427.7 E
T_{11} ($I_2F_1P_2$)	16.7 ABCD	40.0 AB	66.7 ABC	75.0 AB	49.6	508.6 D
T_{12} ($I_2F_1P_3$)	20.0 ABCD	50.0 AB	75.0 AB	80.0 AB	56.3	583.3 BC
T_{13} ($I_2F_2P_1$)	13.3 BCD	30.0 BC	58.3 BC	66.7 BC	42.1	427.7 E
T_{14} ($I_2F_2P_2$)	16.7 ABCD	40.0 AB	66.7 ABC	75.0 AB	49.6	508.6 D
T_{15} ($I_2F_2P_3$)	30.0 A	50.0 AB	75.0 AB	80.0 AB	58.8	600.0 B
T_{16} ($I_2F_3P_1$)	13.3 BCD	30.0 BC	58.3 BC	66.7 BC	42.1	427.7 E
T_{17} ($I_2F_3P_2$)	16.7 ABCD	40.0 AB	66.7 ABC	75.0 AB	49.6	508.6 D
T_{18} ($I_2F_3P_3$)	23.3 ABC	50.0 AB	75.0 AB	80.0 AB	57.1	588.9 BC

(Table 1 cont.)

Table 1(cont.) Effect of host management on onion downy mildew control during 1998-99 (Mean Disease Severity).

T_{19} ($I_3F_1P_1$)	13.3 BCD	30.0 BC	58.3 BC	66.7 BC	42.1	427.7 E
T_{20} ($I_3F_1P_2$)	16.7 ABCD	40.0 AB	66.7 ABC	75.0 AB	49.6	508.6 D
T_{21} ($I_3F_1P_3$)	30.0 A	50.0 AB	75.0 AB	80.0 AB	58.8	600.0 B
T_{22} ($I_3F_2P_1$)	6.7 D	13.3 C	30.0 D	40.0 D	22.5	222.2 G
T_{23} ($I_3F_2P_2$)	16.7 ABCD	40.0 AB	66.7 ABC	75.0 AB	49.6	508.6 D
T_{24} ($I_3F_2P_3$)	30.0 A	50.0 AB	75.0 AB	80.0 AB	58.8	600.0 B
T_{25} ($I_3F_3P_1$)	16.7 ABCD	40.0 AB	66.7 ABC	75.0 AB	49.6	508.6 D
T_{26} ($I_3F_3P_2$)	26.7 AB	48.3 AB	66.7 ABC	75.0 AB	54.2	552.9 C
T_{27} ($I_3F_3P_3$)	30.0 A	58.3 A	80.0 A	85.0 A	63.3	652.7 A
Mean	18.2	39.6	65.2	72.6	48.9	500.8
LSD value	14.4	23.6	19.5	15.1	-	37.7
CV (%)	47.7	35.9	18.0	12.5	-	4.5

I_1 = six irrigations/season; I_2 = seven irrigations/season and I_3 = eight irrigations/season
F_1 = NPK 90:60:30 kg/ha; F_2 = NPK 120:90:60 kg/ha and F_3 = NPK 150:120:90 kg/ha
P_1 = 0.5 million plants/ha; P_2 = 0.75 million plants/ha and P_3 = 1.0 million plants/ha
[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 2. **Effect of host management on onion downy mildew control during 1998-99 (Replicated data of bulb size).**

Treatment		Replications			Mean
		1	2	3	
T_1	$(I_1F_1P_1)$	5.0	4.2	4.5	4.6 DE[1]
T_2	$(I_1F_1P_2)$	4.6	4.0	4.8	4.5 DEF
T_3	$(I_1F_1P_3)$	4.2	4.5	4.8	4.5 DEF
T_4	$(I_1F_2P_1)$	3.9	4.0	3.8	3.9 IJK
T_5	$(I_1F_2P_2)$	4.5	4.2	4.3	4.3 DEFG
T_6	$(I_1F_2P_3)$	3.7	3.7	4.2	3.9 IJK
T_7	$(I_1F_3P_1)$	4.6	4.8	4.5	4.6 CD
T_8	$(I_1F_3P_2)$	4.2	4.3	4.7	4.4 DEF
T_9	$(I_1F_3P_3)$	4.0	3.7	4.2	3.9 HIJ
T_{10}	$(I_2F_1P_1)$	5.3	4.7	4.8	4.9 BC
T_{11}	$(I_2F_1P_2)$	4.3	3.8	4.0	4.0 GHIJ
T_{12}	$(I_2F_1P_3)$	3.8	3.3	3.3	3.5 MN
T_{13}	$(I_2F_2P_1)$	4.5	4.7	4.7	4.6 CD
T_{14}	$(I_2F_2P_2)$	4.3	4.3	4.3	4.3 EFG
T_{15}	$(I_2F_2P_3)$	3.8	3.8	3.8	3.8 IJKL
T_{16}	$(I_2F_3P_1)$	5.3	5.2	4.8	5.1 B
T_{17}	$(I_2F_3P_2)$	4.3	4.5	4.0	4.3 EFGH
T_{18}	$(I_2F_3P_3)$	3.7	3.8	3.7	3.7 JKLM
T_{19}	$(I_3F_1P_1)$	5.2	5.2	5.0	5.1 B
T_{20}	$(I_3F_1P_2)$	4.3	4.2	4.2	4.2 FGH

(Table 2 cont.)

Table 2(cont.) **Effect of host management on onion downy mildew control during 1998-99 (Replicated data of bulb size)**

T_{21}	$(I_3F_1P_3)$	3.3	3.7	3.5	3.5 LMN
T_{22}	$(I_3F_2P_1)$	6.0	6.0	6.2	6.1 A
T_{23}	$(I_3F_2P_2)$	4.3	4.0	4.5	4.3 EFGH
T_{24}	$(I_3F_2P_3)$	3.3	3.2	3.7	3.4 N
T_{25}	$(I_3F_3P_1)$	5.5	5.0	4.7	5.1 B
T_{26}	$(I_3F_3P_2)$	4.3	4.2	3.7	4.1 GHI
T_{27}	$(I_3F_3P_3)$	3.7	3.7	3.5	3.6 KLMN
	Mean	4.4	4.2	4.3	4.3

I_1 = six irrigations/season; I_2 = seven irrigations/season and I_3 = eight irrigations/season
F_1 = NPK 90:60:30 kg/ha; F_2 = NPK 120:90:60 kg/ha and F_3 = NPK 150:120:90 kg/ha
P_1 = 0.5 million plants/ha; P_2 = 0.75 million plants/ha and P_3 = 1.0 million plants/ha
[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 3. **Effect of host management on onion downy mildew control during 1998-99 (Replicated data of bulb number).**

	Treatment	Replications			Mean
		1	2	3	
T_1	$(I_1F_1P_1)$	39	35	35	36.3 FGHIJ[1]
T_2	$(I_1F_1P_2)$	40	50	40	43.3 FGHIJ
T_3	$(I_1F_1P_3)$	58	60	47	55.0 DEF
T_4	$(I_1F_2P_1)$	25	34	42	33.7 GHIJ
T_5	$(I_1F_2P_2)$	47	52	40	46.3 FGHIJ
T_6	$(I_1F_2P_3)$	73	83	56	70.7 BCD
T_7	$(I_1F_3P_1)$	21	30	38	29.7 IJ
T_8	$(I_1F_3P_2)$	40	34	27	33.7 GHIJ
T_9	$(I_1F_3P_3)$	85	58	65	69.3 CDE
T_{10}	$(I_2F_1P_1)$	26	41	40	35.7 FGHIJ
T_{11}	$(I_2F_1P_2)$	48	44	49	47.0 FGHIJ
T_{12}	$(I_2F_1P_3)$	100	81	85	88.7 ABC
T_{13}	$(I_2F_2P_1)$	33	34	29	32.0 HIJ
T_{14}	$(I_2F_2P_2)$	50	44	62	52.0 DEFGH
T_{15}	$(I_2F_2P_3)$	99	125	59	94.3 A
T_{16}	$(I_2F_3P_1)$	32	28	26	28.7 J
T_{17}	$(I_2F_3P_2)$	49	46	54	49.7 EFGHI
T_{18}	$(I_2F_3P_3)$	77	90	104	90.3 AB
T_{19}	$(I_3F_1P_1)$	24	28	38	30.0 IJ
T_{20}	$(I_3F_1P_2)$	54	51	56	53.7 DEFG

(Table 3 cont.)

Table 3(cont.) **Effect of host management on onion downy mildew control during 1998-99 (Replicated data of bulb number)**

T_{21}	$(I_3F_1P_3)$	77	84	69	76.7 ABC
T_{22}	$(I_3F_2P_1)$	35	34	33	34.0 GHIJ
T_{23}	$(I_3F_2P_2)$	39	62	56	52.3 DEFGH
T_{24}	$(I_3F_2P_3)$	65	90	123	92.7 A
T_{25}	$(I_3F_3P_1)$	39	23	29	30.3 IJ
T_{26}	$(I_3F_3P_2)$	42	66	59	55.7 DEF
T_{27}	$(I_3F_3P_3)$	86	98	65	83.0 ABC
	Mean	51.9	55.7	52.8	53.5

I_1 = six irrigations/season; I_2 = seven irrigations/season and I_3 = eight irrigations/season
F_1 = NPK 90:60:30 kg/ha; F_2 = NPK 120:90:60 kg/ha and F_3 = NPK 150:120:90 kg/ha
P_1 = 0.5 million plants/ha; P_2 = 0.75 million plants/ha and P_3 = 1.0 million plants/ha
[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 4. **Effect of host management on onion downy mildew control during 1998-99 (Replicated data on bulb yield).**

Treatment		Replications			Mean
		1	2	3	
T_1	$(I_1F_1P_1)$	7.0	8.0	6.0	7.0 E[1]
T_2	$(I_1F_1P_2)$	9.0	10.0	8.0	9.0 CDE
T_3	$(I_1F_1P_3)$	11.0	11.0	8.0	10.0 BCDE
T_4	$(I_1F_2P_1)$	16.0	10.0	6.0	10.7 BCDE
T_5	$(I_1F_2P_2)$	8.0	12.0	7.0	9.0 CDE
T_6	$(I_1F_2P_3)$	13.0	11.0	6.0	10.0 BCDE
T_7	$(I_1F_3P_1)$	5.0	6.5	8.0	6.5 E
T_8	$(I_1F_3P_2)$	8.0	7.0	5.0	6.7 E
T_9	$(I_1F_3P_3)$	11.0	11.0	12.0	11.3 BCDE
T_{10}	$(I_2F_1P_1)$	6.0	8.0	9.0	7.7 DE
T_{11}	$(I_2F_1P_2)$	16.0	5.0	6.0	9.0 CDE
T_{12}	$(I_2F_1P_3)$	15.0	14.0	12.0	13.7 BC
T_{13}	$(I_2F_2P_1)$	16.0	8.0	7.5	10.5 BCDE
T_{14}	$(I_2F_2P_2)$	16.0	9.0	8.0	11.0 BCDE
T_{15}	$(I_2F_2P_3)$	11.0	20.0	10.0	13.7 BC
T_{16}	$(I_2F_3P_1)$	14.0	5.0	7.0	8.7 CDE
T_{17}	$(I_2F_3P_2)$	12.0	7.0	8.0	9.0 CDE
T_{18}	$(I_2F_3P_3)$	15.0	13.0	7.0	11.7 BCDE
T_{19}	$(I_3F_1P_1)$	7.8	10.0	6.0	7.9 DE
T_{20}	$(I_3F_1P_2)$	12.0	12.0	10.0	11.3 BCDE

(Table 4 cont.)

Table 4(cont.) Effect of host management on onion downy mildew control during 1998-99 (Replicated data of bulb yield)

T_{21}	$(I_3F_1P_3)$	15.0	6.0	10.0	10.3 BCDE
T_{22}	$(I_3F_2P_1)$	20.0	28.0	19.0	22.3 A
T_{23}	$(I_3F_2P_2)$	7.0	11.0	17.0	11.7 BCDE
T_{24}	$(I_3F_2P_3)$	3.0	13.0	15.0	10.3 BCDE
T_{25}	$(I_3F_3P_1)$	10.0	16.0	7.0	11.0 BCD
T_{26}	$(I_3F_3P_2)$	10.0	16.0	12.0	12.7 BCD
T_{27}	$(I_3F_3P_3)$	12.0	14.9	18.0	14.9 D
	Mean	11.3	11.2	9.4	10.7

I_1 = six irrigations/season; I_2 = seven irrigations/season and I_3 = eight irrigations/season

F_1 = NPK 90:60:30 kg/ha; F_2 = NPK 120:90:60 kg/ha and F_3 = NPK 150:120:90 kg/ha

P_1 = 0.5 million plants/ha; P_2 = 0.75 million plants/ha and P_3 = 1.0 million plants/ha

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

APPENDIX-VII

Table 1. Influence of intercropping on downy mildew control in onion during 1998-99 (Mean disease severity).

Treatment	Disease Severity Scoring (%)				Mean disease severity	Mean AUDPC calculated
	26.03.99	05.04.99	15.04.99	25.04.99		
T_1 (Onion)	15.0	27.5	56.3	68.8	41.9	419.0 C[1]
T_2 (Onion+Garlic)	17.5	35.0	62.5	75.0	47.5	479.2 B
T_3 (Onion+Pea)	15.0	35.0	62.5	68.8	45.3	464.7 B
T_4 (Onion+Wheat)	17.5	42.5	68.8	75.0	50.9	525.2 A
T_5 (Onion+Pea+Garlic)	17.5	42.5	68.8	75.0	50.9	525.2 A
T_6 (Onion+Pea+Wheat)	17.5	42.5	68.8	75.0	50.9	525.2 A
T_7 (Onion+Garlic+Wheat)	17.5	42.5	68.8	75.0	50.9	525.2 A
T_8 (Onion+Pea+Garlic+Wheat)	17.5	42.5	68.8	75.0	50.9	525.2 A
Mean	16.9	38.9	65.6	73.4	48.7	498.6
LSD value	-	-	-	-	-	19.5
CV (%)	28.6	36.8	18.1	8.7	-	2.2

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 2. Influence of intercropping on downy mildew control in onion during 1998-99 (Replicated Data on bulb size).

Treatment		Replications				Mean
		1	2	3	4	
T_1	(Onion)	4.9	5.1	4.7	5.2	4.9 A[1]
T_2	(Onion+Garlic)	4.1	4.2	3.7	4.0	4.0 BC
T_3	(Onion+Pea)	4.4	4.6	4.6	5.4	4.8 A
T_4	(Onion+Wheat)	3.5	3.1	3.1	4.0	3.4 D
T_5	(Onion+Pea+Garlic)	4.2	3.8	3.9	4.8	4.2 B
T_6	(Onion+Pea+Wheat)	3.7	3.3	3.6	4.3	3.7 CD
T_7	(Onion+Garlic+Wheat)	3.7	3.5	3.7	3.8	3.7 CD
T_8	(Onion+Pea+Garlic+Wheat)	4.0	4.0	4.1	4.3	4.1 B
	Mean	4.1	3.9	3.9	4.5	4.1

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 3. Influence of intercropping on downy mildew control in onion during 1998-99 (Replicated Data on bulb number).

Treatment		Replications				Mean
		1	2	3	4	
T_1	(Onion)	34	35	37	34	35.0 A[1]
T_2	(Onion+Garlic)	21	32	18	25	24.0 B
T_3	(Onion+Pea)	28	20	22	30	25.0 B
T_4	(Onion+Wheat)	13	13	19	13	14.5 C
T_5	(Onion+Pea+Garlic)	22	31	22	24	24.8 B
T_6	(Onion+Pea+Wheat)	15	23	22	19	19.8 BC
T_7	(Onion+Garlic+Wheat)	21	17	26	13	19.3 BC
T_8	(Onion+Pea+Garlic+Wheat)	23	18	16	23	20.0 BC
	Mean	22.1	23.6	22.8	22.6	22.8

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 4. Influence of intercropping on downy mildew control in onion during 1998-99 (Replicated Data on bulb yield)

Treatment		Replications				Mean
		1	2	3	4	
T_1	(Onion)	18.5	15.6	13.5	16.0	15.9 A[1]
T_2	(Onion+Garlic)	10.0	7.0	12.5	9.5	9.8 BC
T_3	(Onion+Pea)	7.0	8.0	12.0	5.6	8.2 BC
T_4	(Onion+Wheat)	5.0	3.1	4.5	3.2	3.9 D
T_5	(Onion+Pea+Garlic)	9.5	7.0	16.5	8.0	10.3 B
T_6	(Onion+Pea+Wheat)	12.5	5.0	13.0	5.8	9.1 BC
T_7	(Onion+Garlic+Wheat)	10.5	3.5	5.2	4.0	5.8 CD
T_8	(Onion+Pea+Garlic+Wheat)	16.0	6.5	4.6	6.0	8.3 BC
	Mean	11.1	6.9	10.2	7.3	8.9

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 5. Influence of intercropping on downy mildew control in onion during 1998-99 (Replicated data of pea yield)

Treatment		Replications				Mean
		1	2	3	4	
T_1	(Onion)	0	0	0	0	0.0 B[1]
T_2	(Onion+Garlic)	0	0	0	0	0.0 B
T_3	(Onion+Pea)	4.4	6.1	5.8	5.0	5.3 A
T_4	(Onion+Wheat)	0	0	0	0	0.0 B
T_5	(Onion+Pea+Garlic)	5.4	5.4	4.7	9.0	6.1 A
T_6	(Onion+Pea+Wheat)	3.6	5.5	3.6	4.6	4.3 A
T_7	(Onion+Garlic+Wheat)	0	0	0	0	0.0 B
T_8	(Onion+Pea+Garlic+Wheat)	4.9	6.4	2.8	10.4	6.1 A
	Mean	2.3	2.9	2.1	3.6	2.7

[1] Figures followed by different letters are significantly different ($P < 0.05$) from one another

Table 6. Influence of intercropping on downy mildew control in onion during 1998-99 (Replicated data of garlic yield)

Treatment		Replications				Mean
		1	2	3	4	
T_1	(Onion)	0	0	0	0	0.0 D[1]
T_2	(Onion+Garlic)	10.0	11.7	9.8	12.5	11.0 A
T_3	(Onion+Pea)	0	0	0	0	0.0 D
T_4	(Onion+Wheat)	0	0	0	0	0.0 D
T_5	(Onion+Pea+Garlic)	8.8	8.8	10.0	8.3	8.9 B
T_6	(Onion+Pea+Wheat)	0	0	0	0	0.0 D
T_7	(Onion+Garlic+Wheat)	9.2	9.7	8.3	11.7	9.7 B
T_8	(Onion+Pea+Garlic+Wheat)	3.5	3.8	3.0	3.3	3.4 C
	Mean	3.9	4.3	3.9	4.5	4.1

[1] Figures followed by different letters are significantly different ($P < 0.05$) from one another

Table 7. **Influence of intercropping on downy mildew control in onion during 1998-99 (Replicated data of wheat yield).**

Treatment		Replications				Mean
		1	2	3	4	
T_1	(Onion)	0	0	0	0	0.0 B[1]
T_2	(Onion+Garlic)	0	0	0	0	0.0 B
T_3	(Onion+Pea)	0	0	0	0	0.0 B
T_4	(Onion+Wheat)	5.4	5.8	5.8	4.2	5.3 A
T_5	(Onion+Pea+Garlic)	0	0	0	0	0.0 B
T_6	(Onion+Pea+Wheat)	4.3	6.5	7.5	5.0	5.8 A
T_7	(Onion+Garlic+Wheat)	5.8	3.3	3.4	5.3	4.5 A
T_8	(Onion+Pea+Garlic+Wheat)	6.5	6.5	3.5	3.5	5.0 A
	Mean	2.8	2.8	2.5	2.3	2.6

[1] Figures followed by different letters are significantly different ($P < 0.05$) from one another

APPENDIX-VIII

Table 1. Relative efficacy of weed control methods in controlling onion downy mildew during 1998-99 (Mean disease severity).

	Treatment	Disease Severity Scoring (%)				Mean disease severity	Mean AUDPC calculated
		26.03.99	05.04.99	15.04.99	25.04.99		
T_1	Roanstar (@ 4 ml/L + weeding)	20.0 BC	31.3 ABCD	59.4 A	65.6 AB	44.1	445.0 CD[1]
T_2	Roanstar (@ 4 ml/L + no weeding)	27.5 AB	38.8 AB	65.6 A	73.8 AB	51.4	516.8 AB
T_3	Roanstar (@ 5 ml/L + weeding)	16.3 C	20.0 D	38.8 C	42.5 C	29.4	294.0 E
T_4	Roanstar (@ 5 ml/L + no weeding)	27.5 AB	35.0 ABC	62.5 A	68.8 AB	48.5	485.5 BC
T_5	Roanstar (@ 6 ml/L + weeding)	17.5 BC	27.5 BCD	56.3 AB	62.5 B	40.9	412.7 D
T_6	Roanstar (@ 6 ml/L + no weeding)	31.3 A	38.8 AB	65.6 A	71.9 AB	51.9	520.0 AB
T_7	No herbicide + weeding (Check 1)	17.5 BC	23.8 CD	42.5 BC	45.6 C	32.4	326.2 E
T_8	No herbicide + no weeding (Double zero - Check 2)	35.0 A	42.5 A	68.8 A	78.8 A	56.3	560.7 A
	Mean	24.1	32.2	57.4	63.7	44.4	445.1
	LSD value	10.4	13.8	14.6	14.8	-	56.8
	CV (%)	42.2	41.8	24.8	22.7	-	6.8

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 2. Relative efficacy of weed control methods in controlling onion downy mildew during 1998-99 (Replicated data on bulb size).

Treatment		Replications								Mean
		1	2	3	4	5	6	7	8	
T_1	Roanstar (@ 4 ml/L + weeding)	4.3	4.7	4.7	5.0	4.8	5.0	4.8	5.0	4.8 B[1]
T_2	Roanstar (@ 4 ml/L + no weeding)	4.0	4.0	4.0	4.2	3.8	4.0	3.8	4.0	3.9 C
T_3	Roanstar (@ 5 ml/L + weeding)	5.7	5.5	6.5	5.8	6.2	6.3	6.5	6.0	6.1 A
T_4	Roanstar (@ 5 ml/L + no weeding)	4.7	4.3	4.3	4.7	5.0	5.2	4.5	4.7	4.7 B
T_5	Roanstar (@ 6 ml/L + weeding)	4.3	5.0	4.7	5.3	4.7	4.5	4.7	5.2	4.8 B
T_6	Roanstar (@ 6 ml/L + no weeding)	3.8	4.2	3.8	4.7	3.7	3.5	4.0	3.8	3.9 C
T_7	No herbicide + weeding (Check 1)	5.3	5.5	6.2	6.3	6.2	6.5	6.5	6.0	6.1 A
T_8	No herbicide + no weeding (Double zero - Check 2)	3.2	3.5	3.5	4.0	3.5	3.0	3.3	3.2	3.4 D
	Mean	4.4	4.6	4.7	5.0	4.7	4.8	4.8	4.7	4.7

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 3. Relative efficacy of weed control methods in controlling onion downy mildew during 1998-99 (Replicated data of bulb number).

Treatment		Replications								Mean
		1	2	3	4	5	6	7	8	
T_1	Roanstar (@ 4 ml/L + weeding)	25	33	32	32	39	24	29	32	30.8 BC[1]
T_2	Roanstar (@ 4 ml/L + no weeding)	25	27	31	24	17	22	29	32	25.9 CD
T_3	Roanstar (@ 5 ml/L + weeding)	39	33	35	35	39	38	32	44	36.9 A
T_4	Roanstar (@ 5 ml/L + no weeding)	16	34	33	28	29	14	28	35	27.1 CD
T_5	Roanstar (@ 6 ml/L + weeding)	29	24	25	28	26	29	27	28	27.0 CD
T_6	Roanstar (@ 6 ml/L + no weeding)	29	15	23	31	23	10	26	26	22.9 DE
T_7	No herbicide + weeding (Check 1)	37	39	34	35	28	39	32	34	34.8 AB
T_8	No herbicide + no weeding (Double zero - Check 2)	19	26	30	24	10	20	12	23	20.5 E
	Mean	27.4	28.9	30.4	29.6	26.4	24.5	26.9	31.8	28.2

[1] Figures followed by different letters are significantly different ($P<0.05$) from one another

Table 4. Relative efficacy of weed control methods in controlling onion downy mildew during 1998-99 (Replicated data on bulb yield).

Treatment		Replications								Mean
		1	2	3	4	5	6	7	8	
T_1	Roanstar (@ 4 ml/L + weeding)	18.0	17.0	8.0	7.5	10.8	17.0	16.5	7.5	12.8 AB[1]
T_2	Roanstar (@ 4 ml/L + no weeding)	6.5	10.0	16.5	6.0	15.0	13.0	6.5	7.0	10.1 BC
T_3	Roanstar (@ 5 ml/L + weeding)	18.0	18.5	15.0	18.0	15.0	15.0	17.0	14.0	16.3 A
T_4	Roanstar (@ 5 ml/L + no weeding)	15.8	8.0	7.0	7.0	7.0	14.0	16.0	6.0	10.1 BC
T_5	Roanstar (@ 6 ml/L + weeding)	14.5	7.0	15.6	8.0	5.1	6.0	13.0	9.0	9.8 BC
T_6	Roanstar (@ 6 ml/L + no weeding)	10.5	5.0	10.2	7.0	4.8	14.0	6.5	8.0	8.3 C
T_7	No herbicide + weeding (Check 1)	18.0	18.0	13.0	12.0	17.0	16.0	16.0	18.0	16.0 A
T_8	No herbicide + no weeding (Double zero - Check 2)	3.0	4.5	10.8	3.0	2.0	12.0	3.0	12.5	6.4 C
	Mean	13.0	11.0	12.0	8.6	9.6	13.4	11.8	10.3	11.2

[1] Figures followed by different letters are significantly different ($P < 0.05$) from one another

APPENDIX-IX

Table 1. Consolidated data on severity of downy mildew (AUDPC) and onion yield showing in the difference between multilocation testing of IDMM versus FOPs during 1999-2000.

Locations	Integrated Disease Management Model (IDMM)				Farmer's Own Practices (FOP)			
	Mean[2]							
	AUDPC[1]	Bulb size (cm)	Bulb number (m^2)	Bulb yield (t/ha)	AUDPC	Bulb size (cm)	Bulb number/ m^2	Bulb yield (t/ha)
1. Miana	177.0 A	6.9 B	49.6 NS	47.6 B	496.5 A	3.2 B	85.7 NS	27.3 B
2. Zakhi Qabristan	188.2 A	7.0 B	49.7 NS	48.9 B	491.2 A	3.3 B	85.3 NS	27.9 B
3. Zarif Shah	116.0 B	8.2 A	49.9 NS	60.2 A	256.8 B	4.2 A	86.3 NS	32.0 A
4. Zoor Manday	113.0 B	8.3 A	49.5 NS	60.3 A	245.2 B	4.2 A	86.4 NS	33.1 A
Mean	148.5	7.6	49.7	54.2	372.4	3.7	85.9	30.1
LSD (Value)	42.1	0.2	-	2.2	99.0	0.2	-	1.4
CV (%)	14.2	1.2	1.4	1.9	13.3	4.7	3.3	3.5

[1] AUDPC (Area Under Disease Progress Curve) = $\sum_{n-1}^{1}\{(X_i+X_{i-1})/2\}\{t_i-t_{i-1}\}$

whereas X_i = present disease severity; X_{i-1} = previous disease severity and t_i-t_{i-1} = time difference between two consective disease severities.

' Figures in parenthesis for AUDPC indicate decrease and those for yield. size and bulb number show increase over the untreated check.

[2] = Mean represent average of four replications

		30.03.2000		08.04.2000		18.04.2000	
		IDMM	FOPs	IDMM	FOPs	IDMM	FOPs
1	Miana	7.5 A	7.5 AB	15.3 A	41.6 A	25.6 A	63.3
2	Zarif Shah	6.1 B	6.9 AB	12.2 B	13.8 B	15.6 B	31.3
3·	Zakhi Qabristan	8.1 A	8.1 A	16.9 A	40.6 A	26.6 A	63.3
4	Zoor Manday	5.9 B	6.4 B	11.9 B	12.8 B	15.3 B	29.4
	Mean	6.9	7.2	14.1	27.2	20.8	46.8
	LSD value	1.3	1.3	2.1	4.1	4.9	7.3
	CV (%)	33.0	35.1	34.5	42.8	47.1	30.4

Table 3. Effect of Multilocation testing of IDMM versus FOPs on disease severity and yield in onion (Replciated data at Miana on bulb size).

Quadratic Unit Number	INTEGRATED DISEASE MANAGEMENT MODEL (IDMM)					FARMER'S OWN PRACTICES (FOPs)				
	Replications				Mean	Replications				Mean
	1	2	3	4		1	2	3	4	
1	7.1	7.1	6.9	6.9	7.0	3.5	3.1	3.2	3.4	3.3
2	6.9	7.1	6.9	7.1	7.0	3.1	3.0	3.1	3.0	3.1
3	7.1	6.9	6.9	7.1	7.0	3.0	3.1	3.0	3.1	3.1
4	7.1	6.9	7.1	6.9	7.0	3.2	3.1	3.2	3.1	3.2
5	6.9	6.9	6.8	6.8	6.9	3.1	3.2	3.1	3.2	3.2
6	6.8	6.9	6.9	6.8	6.9	3.4	3.5	3.4	3.5	3.5
7	6.9	6.8	6.8	6.9	6.9	3.5	3.4	3.5	3.4	3.5
8	7.0	7.0	7.0	7.0	7.0	3.2	3.2	3.2	3.2	3.2
Mean	6.9	6.9	6.9	6.9	6.9	3.3	3.2	3.2	3.2	3.2

Table 4. Effect of Multilocation testing of IDMM versus FOPs on disease severity and yield in onion (Replciated data at Zarif Shah on bulb size).

Quadratic Unit Number	INTEGRATED DISEASE MANAGEMENT MODEL (IDMM)					FARMER'S OWN PRACTICES (FOPs)				
	Replications				Mean	Replications				Mean
	1	2	3	4		1	2	3	4	
1	8.5	8.4	8.0	8.1	8.3	4.0	4.4	4.1	4.4	4.2
2	8.4	8.4	8.5	8.5	8.5	4.0	4.0	4.0	4.0	4.0
3	8.0	8.0	8.0	8.1	8.0	4.2	4.2	4.2	4.1	4.2
4	8.1	8.0	8.1	8.1	8.1	4.4	4.5	4.4	4.5	4.5
5	8.6	8.6	8.6	8.6	8.6	4.1	4.5	4.1	4.5	4.3
6	8.5	8.5	8.5	8.5	8.5	4.5	4.1	4.5	4.1	4.3
7	8.1	8.1	8.1	8.1	8.1	4.0	4.0	3.8	3.8	3.9
8	8.2	8.2	8.2	8.1	8.2	3.8	3.8	4.0	4.0	3.9
Mean	8.3	8.3	8.3	8.3	8.2	4.1	4.2	4.1	4.2	4.2

Table 5. Effect of Multilocation testing of IDMM versus FOPs on disease severity and yield in onion (Replciated data at Zakhi Qabristan on bulb size).

Quadratic Unit Number	INTEGRATED DISEASE MANAGEMENT MODEL (IDMM)					FARMER'S OWN PRACTICES (FOPs)				
	Replications				Mean	Replications				Mean
	1	2	3	4		1	2	3	4	
1	7.0	7.0	7.1	7.2	7.1	3.6	3.0	3.0	3.5	3.2
2	7.0	7.1	7.1	7.1	7.1	3.0	3.5	3.5	3.0	3.3
3	6.9	6.9	7.0	7.0	6.9	3.0	3.6	3.0	3.6	3.3
4	7.0	7.0	6.9	6.9	6.9	3.6	3.0	3.6	3.0	3.3
5	6.9	7.0	6.9	7.0	6.9	3.4	3.4	3.5	3.5	3.5
6	7.0	6.9	7.0	6.9	6.9	3.5	3.5	3.4	3.4	3.5
7	7.1	7.1	7.0	7.0	7.1	3.1	3.1	3.0	3.0	3.1
8	7.0	7.0	7.1	7.1	7.1	3.0	3.0	3.1	3.1	3.1
Mean	6.9	7.0	7.0	7.0	7.0	3.3	3.3	3.3	3.3	3.3

Table 6. Effect of Multilocation testing of IDMM versus FOPs on disease severity and yield in onion (Replciated data at Zoor Mandi on bulb size).

Quadratic Unit Number	INTEGRATED DISEASE MANAGEMENT MODEL (IDMM)					FARMER'S OWN PRACTICES (FOPs)				
	Replications				Mean	Replications				Mean
	1	2	3	4		1	2	3	4	
1	8.6	8.5	8.1	8.2	8.4	4.1	4.5	4.2	4.5	4.3
2	8.5	8.5	8.5	8.5	8.5	4.0	4.4	4.2	4.5	4.3
3	8.1	8.0	8.1	8.0	8.1	4.5	4.5	4.5	4.5	4.5
4	8.2	8.2	8.2	8.2	8.2	4.5	4.1	4.5	4.1	4.3
5	8.6	8.5	8.6	8.5	8.6	4.1	4.5	4.1	4.5	4.3
6	8.5	8.6	8.5	8.6	8.6	4.2	4.2	4.2	4.2	4.2
7	8.1	8.2	81	8.2	8.2	4.1	4.1	3.9	3.9	4.0
8	8.2	8.1	8.2	8.1	8.2	3.9	3.9	4.1	4.1	4.0
Mean	8.4	8.3	8.3	8.3	8.3	4.2	4.3	4.2	4.3	4.2

Table 7. Effect of Multilocation testing of IDMM versus FOPs on disease severity and yield in onion (Replciated data at Miana on bulb number).

Quadratic Unit Number	INTEGRATED DISEASE MANAGEMENT MODEL (IDMM)					FARMER'S OWN PRACTICES (FOPs)				
	Replications				Mean	Replications				Mean
	1	2	3	4		1	2	3	4	
1	50	49	50	49	49.5	87	85	85	84	85.3
2	49	50	51	49	49.8	85	85	87	84	85.3
3	50	50	50	49	49.8	87	90	90	85	88.0
4	50	49	49	50	49.5	90	85	85	85	86.3
5	49	50	50	50	49.8	84	85	85	90	86.0
6	49	50	49	50	49.5	85	85	84	85	84.8
7	50	49	50	49	49.5	85	84	85	85	84.8
8	50	49	50	50	49.5	84	86	85	85	85.0
Mean	49.6	49.5	49.9	49.5	49.6	85.9	85.6	85.8	85.4	85.7

Table 8. Effect of Multilocation testing of IDMM versus FOPs on disease severity and yield in onion (Replciated data at Zarif Shah on bulb number).

Quadratic Unit Number	INTEGRATED DISEASE MANAGEMENT MODEL (IDMM)					FARMER'S OWN PRACTICES (FOPs)				
	Replications				Mean	Replications				Mean
	1	2	3	4		1	2	3	4	
1	50	50	51	50	50.3	85	85	90	80	85.0
2	49	49	50	49	49.3	83	93	95	85	89.0
3	48	50	50	50	49.5	85	85	86	90	86.5
4	50	50	48	50	49.5	90	86	85	85	86.5
5	50	49	49	51	49.8	85	87	85	88	86.3
6	51	50	49	51	50.3	80	88	87	89	86.0
7	51	49	50	50	50.0	85	90	85	88	87.0
8	49	50	51	52	50.5	90	83	90	85	87.0
Mean	49.8	49.6	49.8	50.4	49.9	85.4	87.1	87.9	86.3	86.7

Table 9. Effect of Multilocation testing of IDMM versus FOPs on disease severity and yield in onion (Replciated data at Zakhi Qabristan on bulb number).

Quadratic Unit Number	INTEGRATED DISEASE MANAGEMENT MODEL (IDMM)					FARMER'S OWN PRACTICES (FOPs)				
	Replications				Mean	Replications				Mean
	1	2	3	4		1	2	3	4	
1	50	51	50	50	50.3	87	85	87	87	86.5
2	50	49	49	50	49.5	85	85	87	85	85.5
3	51	50	50	49	49.8	83	90	84	86	85.8
4	50	49	50	49	49.5	84	85	85	85	84.8
5	49	49	49	50	49.3	90	84	85	84	85.8
6	49	50	50	50	49.8	85	84	85	85	84.8
7	50	50	50	49	49.8	85	85	84	85	84.8
8	50	50	49	49	49.5	84	85	85	84	84.5
Mean	49.9	49.8	49.6	49.5	49.7	85.4	85.4	85.3	85.4	85.3

Table 10. Effect of Multilocation testing of IDMM versus FOPs on disease severity and yield in onion (Replciated data at Zoor Mandi on bulb number).

Quadratic Unit Number	INTEGRATED DISEASE MANAGEMENT MODEL (IDMM)					FARMER'S OWN PRACTICES (FOPs)				
	Replications				Mean	Replications				Mean
	1	2	3	4		1	2	3	4	
1	49	49	49	50	49.3	80	95	80	87	85.5
2	49	50	50	50	49.8	85	80	83	84	83.0
3	50	50	50	49	49.8	90	90	85	85	87.5
4	49	49	50	49	49.3	85	85	87	88	86.3
5	50	50	49	49	49.5	90	85	90	90	88.8
6	49	50	49	50	49.5	85	90	85	90	87.5
7	50	49	50	49	49.5	90	85	85	84	86.0
8	50	50	50	49	49.8	90	85	85	87	86.8
Mean	49.5	49.6	49.8	49.4	49.5	86.9	86.9	85.0	86.9	86.4

Table 11. Effect of Multilocation testing of IDMM versus FOPs on disease severity and yield in onion (Replciated data at Miana on bulb yield).

Quadratic Unit Number	INTEGRATED DISEASE MANAGEMENT MODEL (IDMM)					FARMER'S OWN PRACTICES (FOPs)				
	Replications				Mean	Replications				Mean
	1	2	3	4		1	2	3	4	
1	50	50	45	45	47.5	30	27	28	27	28.0
2	51	47	50	50	49.5	30	28	28	28	28.5
3	50	50	49	50	49.8	27	28	27	27	27.3
4	51	51	51	49	50.5	27	29	29	28	28.3
5	47	47	46	47	46.8	28	29	29	29	28.8
6	48	47	48	47	47.5	29	29	26	25	27.3
7	44	44	45	44	44.3	24	25	27	27	25.8
8	45	45	45	45	45.0	25	25	24	24	24.5
Mean	48.3	47.6	47.4	47.1	47.6	27.5	27.5	27.3	26.9	27.3

Table 12. Effect of Multilocation testing of IDMM versus FOPs on disease severity and yield in onion (Replciated data at Zarif Shah on bulb yield).

Quadratic Unit Number	INTEGRATED DISEASE MANAGEMENT MODEL (IDMM)					FARMER'S OWN PRACTICES (FOPs)				
	Replications				Mean	Replications				Mean
	1	2	3	4		1	2	3	4	
1	64	64	59	63	62.5	33	34	33	33	33.3
2	63	63	62	61	62.3	33	33	32	32	32.5
3	59	59	59	58	58.8	31	31	32	31	31.3
4	61	62	61	62	61.5	32	32	31	31	31.3
5	58	58	57	57	57.5	31	32	32	32	31.8
6	61	62	62	61	61.5	31	31	31	32	31.3
7	59	59	59	58	58.8	32	32	32	32	32.0
8	59	59	58	59	58.8	33	33	32	32	32.5
Mean	60.5	60.8	59.6	59.9	60.2	32.0	32.3	31.9	31.9	32.0

Table 13. Effect of Multilocation testing of IDMM versus FOPs on disease severity and yield in onion (Replciated data at Zakhi Qabristan on bulb yield).

Quadratic Unit Number	INTEGRATED DISEASE MANAGEMENT MODEL (IDMM)					FARMER'S OWN PRACTICES (FOPs)				
	Replications				Mean	Replications				Mean
	1	2	3	4		1	2	3	4	
1	51	51	49	51	50.5	31	28	29	28	29.0
2	52	48	51	51	50.5	31	29	29	29	29.5
3	51	51	51	51	51.0	28	29	28	29	28.5
4	52	52	52	52	52.0	28	30	30	29	29.3
5	48	48	48	48	48.0	29	30	31	31	30.3
6	49	48	49	48	48.5	28	28	25	24	26.3
7	45	45	46	45	45.3	24	25	28	28	26.3
8	46	46	46	46	46.0	25	24	24	23	24.0
Mean	49.3	48.6	49.0	49.0	49.8	28.0	27.9	28.0	27.6	27.9

Table 14. Effect of Multilocation testing of IDMM versus FOPs on disease severity and yield in onion (Replciated data at Zoor Mandi on bulb yield).

Quadratic Unit Number	INTEGRATED DISEASE MANAGEMENT MODEL (IDMM)					FARMER'S OWN PRACTICES (FOPs)				
	Replications				Mean	Replications				Mean
	1	2	3	4		1	2	3	4	
1	65	63	64	58	62.5	34	35	34	34	34.3
2	64	62	63	61	62.5	32	34	32	34	33.0
3	59	58	59	58	58.5	33	33	34	32	33.0
4	62	61	61	62	61.5	33	32	32	32	32.3
5	58	57	58	57	57.5	32	33	33	32	32.5
6	61	62	62	61	61.5	33	34	31	33	32.8
7	59	59	58	59	58.8	34	33	34	33	33.5
8	59	59	59	58	58.8	34	34	32	34	33.5
Mean	60.9	60.1	60.5	59.3	60.3	33.1	33.5	32.8	33.0	33.1