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Effect of Integrated Nutrient Management under Different Irrigation Methods on Soil Properties, Yield and Storability of *rabi* Onion

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Abstract : Field experiments were carried out for three years (2013-15) involving three irrigation methods and six INM treatments comprising of organic manures (Farmyard manure, press-mud compost and vermicompost) in combination with recommended dose of fertilizers (100:50:50 kg ha^{-1} N, P_2O_5 and K_2O) and 125:62.5:25 kg ha^{-1} N, P_2O_5 and K_2O as per soil test along with absolute control replicated thrice in split plot design to study their influence on soil properties and storability of *rabi* onion. The drip irrigation and RDF along with FYM recorded highest plant height, number of leaves, equatorial diameter, polar diameter, bulb yield, water use efficiency and total nutrient uptake in *rabi* onion, highest gross monetary returns, maximum net income, highest B:C ratio (3.91), maximum net extra income and lower total loss during storage of onion over other treatment combinations.

Key words: *Irrigation methods, INM storability, rabi onion*

Introduction

India is the second largest producer of onion in the world with an area of 10.63 lakh hectares and total production of 151.17 lakh MT per annum next only to China. The major onion producing areas in country are located in Maharashtra, Gujarat, Karnataka, Tamil Nadu and Andhra Pradesh. Maharashtra is the largest producer of onion with an area of 4.15 lakh hectares and production of 49.05 lakh tonnes and productivity of11.8 tha^{-1}. Its cultivation is concentrated mainly in Nashik, Pune, Jalgaon, Dhule, Ahmednagar, Solapur and Satara districts (Anonymous 2012).

In onion production, nutrition is one of the most important factors. The use of organic manures has been reported to improve physical, chemical and biological properties of soil and in-turn yield of onions but organic manure alone may not be able to meet the nutritional requirement of high yielding onion cultivars. Yadav *et al.* (2003) emphasized the role of nutrients on vegetative growth, yield and quality of onion. Keeping in view, the significance of organic manures, nutrients and water, the present experiment was carried involving different organic sources with inorganic fertilizers and methods of irrigation for achieving higher productivity of onion without deteriorating the soil.

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Methods and materials

A field experiment was carried out consecutively for three years at AICRP on Irrigation Water Management, M.P.K.V., Rahuri during the *rabi* seasons of 2013-15. Experiment was laid out in a split plot design with three replications with three different irrigation methods (Table 1) coupled with six different Integrated Nutrient Management treatments comprising of organic manures (Farmyard manure, press-mud compost and vermicompost) in combination with recommended dose of fertilizers (100:50:50 kg ha^{-1} N, P_2O_5 and K_2O) and also fertilizer dose (125:62.5:25 kg ha^{-1} N, P_2O_5 and K_2O) as per soil test along with absolute control.

The experimental soil (Vertic Inceptisol, 90 cm deep) had pH 8.35, EC 0.23 dSm^{-1}, organic carbon 0.54 per cent, low in available N, medium in available P and high in available K content, hydraulic conductivity 0.83 cm hr^{-1}, bulk density 1.32 Mg m^{-3} with field capacity of 41.50 per cent and permanent wilting point of 20.35 per cent. The soil and plant samples were analysed for

different parameters before and after the harvest of the crops by using standard methods of analysis (Jackson 1973).

The required quantity of irrigation water through drip and micro sprikler was computed on the basis of 100 per cent crop evapotranspiration and irrigated on alternate day and 50 mm CPE in the surface irrigation method. Nitrogen was applied through urea while P and K were added through single super phosphate and muirate of potash, respectively. The biometric and yield observations were recorded. The data generated was pooled over years and analysed following statistical procedure (Panse and Sukhatme 1985).

Results and Discussion

The plant height and number of leaves at 90 DAT (Days after Transplanting) were significantly higher under drip irrigation at alternate day, while lowest was under surface irrigation (Table 1). INM treatments (RDF) along with FYM recorded highest plant height and number of leaves while lowest was recorded in control treatment. The results are in close agreement with the observations recorded by Jayathilake *et al.* (2002). An increase in plant height and number of leaves facilitated the increased storage of assimilates and in-turn bulb development which results in increased bulb production. The results obtained are in close agreement with the observations recorded by Jayathilake *et al.* (2002) and Khandelwal (2010).

Drip irrigation at alternate day recorded significantly highest equatorial diameter (6.37 cm) and lowest was recorded in surface irrigation. RDF along with FYM recorded highest equatorial diameter of onion bulb, while lowest was recorded under control treatment (Table 1). The drip irrigation at alternate day recorded significantly highest polar diameter (5.67) but was at par with the treatment comprising of RDF along with application of vermicompost. The higher equatorial and polar diameter under drip irrigation and INM treatments might be due to the significant increase in height, number of green leaves and combined effects of both might have helped to accumulate more carbohydrates, resulting in increased equatorial diameter. Since the bulb is the storage organ of the onion and whatever carbohydrates, produced in the leaves are trans-located and stored in the bulb which results in a bigger size of bulb. The drip irrigation at alternate day as per ETc recorded significantly highest bulb yield (34.56 MT ha^{-1}). The lowest yield was recorded under surface irrigation (24.43 MT ha^{-1}). Treatment comprising of RDF and FYM recorded significantly highest bulb yield (39.44 MT) and the lowest was recorded in the control treatment (15.33 $MTha^{-1}$). The application of FYM might have improved soil porosity, availability of nutrients and proliferation of microbes which in-turn increased the yield of onion. Drip irrigation and INM treatment (RDF + FYM) recorded significantly higher onion bulb yield owing to increased vegetative growth parameters and yield contributing characters. Warade *et al.* (1995) also reported similar findings.

The highest total water was applied under surface irrigation at 50 mm CPE (101.11 cm) followed by micro sprinkler irrigation (59.48 cm) and drip irrigation (55.29 cm) at alternate day. Among INM treatments, on an average 72.40 cm of water was applied to all the treatments. Highest water use efficiency was observed under drip irrigation at alternate day on ETc (708 kg ha^{-1}cm) and lowest was in surface irrigation. Among INM treatments, highest WUE was recorded in treatment having RDF along with FYM and lowest was in the control treatment. The highest water saving of 46.84 per cent was observed in drip irrigation while it was 42 per cent under micro sprinkler irrigation.

In INM treatments, the highest water use efficiency was in the treatment RDF + FYM (380 kg ha^{-1} cm) followed by RDF+ VC (332 kg ha^{-1} cm). The lowest water use efficiency was in the control treatment. Overall the water saving percentage in INM treatments was 29.59. These results are in close agreement with Gorantiwar *et al.* (1991), Sonawane (2009) and Tripathi *et al.* (2010).

Balance sheet of nutrients

Balance sheet of nutrients (Table 2) revealed that there was a net positive balance of major nutrients in all the irrigation methods, the highest being under

Table 1. Effect of irrigation methods and INM on different parameters at harvest of *rabi* onion (Pooled)

Treatment	Plant height (cm) at 90 DAT	No. of leaves at 90 DAT	Equatorial diameter (cm) (At harvest)	Polar diameter (cm) (At harvest)	Bulb yield (MT ha^{-1})	Total water applied (cm)	Water use efficiency (kg ha^{-1} cm)	Water saving (%)
a)Irrigation methods								
I_1. Drip irrigation at alternate day as per ETc	59.62	10.34	6.37	5.75	34.56	55.29	708	46.84
I_2. Micro sprinkler irrigation at alternate day as per ETc	55.73	9.71	5.88	4.93	30.06	59.48	580	42.00
I_3. Surface irrigation at 50 mm CPE	43.10	8.00	5.23	4.41	24.43	101.11	251	-
SE±	0.39	0.035	0.014	0.021	0.231			
CD at 5%	1.21	0.10	0.04	0.06	0.71			
b) INM								
F_1. Control	43.30	7.01	4.42	3.90	15.33	72.40	234	
F_2. RDF through NPK	53.16	9.37	5.80	4.97	26.20	72.40	391	
F_3. AST (As per Soil Test)	54.25	9.98	6.22	5.19	31.66	72.40	470	
F_4. RDF through NPK + FYM @ 10 t ha^{-1}	56.84	10.39	6.42	5.67	39.44	72.40	590	
F_5. RDF through NPK + PMC (on the basis of N content of FYM)	53.83	9.67	5.96	5.12	31.53	72.40	482	
F_6. RDF through NPK + Vermicompost (on the basis of N content of FYM)	55.55	9.68	6.15	5.34	33.93	72.40	502	
SE±	1.45	0.24	0.15	0.13	0.81			29.59
CD at 5%	4.09	0.69	0.43	0.37	2.28			
Interaction	NS	NS	NS	0.59	NS			
Mean	52.82	9.35	5.83	5.03	29.68			

Table 2. Balance sheet of nutrients (kg ha^{-1}) under INM and irrigation methods for *rabi* onion

Treatments	Initial nutrients			Nutrients added			Nutrient Removed by uptake			Available nutrient at harvest			Net soil nutrient balance gain/loss		
	N	P	K	N	P_2O_5	K_2O	N	P	K	N	P	K	N	P	K
Irrigation methods (I)															
Drip irrigation at alternate day as per ETc	176	13.25	455	115	74.63	78.80	66.45	19.21	55.84	182.58	17.22	444	41.97	51.45	33.21
Micro sprinkler irrigation at alternate day as per ETc	176	13.25	455	115	74.63	78.80	57.76	16.31	48.98	174.00	18.64	483	59.24	52.93	1.07
Surface irrigation at 50 mm CPE	176	13.25	455	115	74.63	78.80	44.18	12.70	40.90	175.08	18.42	452	71.73	56.75	40.06
INM (F)															
Control	176	13.25	455	00	00	00	28.85	7.83	26.13	175.67	21.08	480	-28.52	-15.66	-51.46
RDF through NPK	176	13.25	455	100	50	50	46.14	13.26	40.80	183.00	19.57	417	46.86	30.42	46.7
AST (As per Soil Test)	176	13.25	455	125	27.29	20.83	57.15	16.87	49.58	173.00	14.75	459	70.85	8.92	-33.58
RDF through NPK + FYM @ 10 t ha^{-1}	176	13.25	455	155	86.83	141.66	79.58	22.87	66.51	181.83	16.50	468	69.59	60.71	61.48
RDF through NPK + PMC (on the basis of N content of FYM)	176	13.25	455	155	175.83	192.66	66.11	18.80	55.43	179.17	18.25	456	85.72	152.03	135.9
RDF through NPK + Vermicompost (on the basis of N content of FYM)	176	13.25	455	155	107.83	67.66	58.97	16.81	53.00	170.67	18.41	480	101.36	85.86	-10.34

Table 3. Cost of cultivation, gross and net income, benefit: cost ratio and net extra income over control due to effect of irrigation Methods and INM on *rabi* onion (pooled)

Treatments	Drip irrigation					Micro sprinkler irrigation					Surface irrigation				
	Cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})	Benefit : cost ratio	Net extra income over control (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})	Benefit : cost ratio	Net extra income over control (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})	Benefit : cost ratio	Net extra income over control (Rs ha^{-1})
F_1 :Control	71468	143523	72055	1.97	00	77804	126815	49011	1.58	00	61013	93955	32942	1.44	00
F_2 :RDF through NPK	77334	238503	161170	3.04	89114	77003	198868	121866	2.53	72854	67137	170362	103225	2.47	70283
F_3 :AST (As per Soil Test)	78198	279837	201639	3.55	129584	78124	251142	173017	3.14	124006	67829	200330	132501	2.90	99559
F_4 :RDF through NPK + FYM @ 10 t ha^{-1}	86439	343773	257335	3.91	185280	86108	314075	227968	3.56	178956	75812	259090	183278	3.33	150336
F_5 :RDF through NPK + PMC (on the basis of N content of FYM)	88407	287320	198913	3.16	126858	88076	251122	163046	2.76	114034	77609	208267	130658	2.57	97716
F_6 :RDF through NPK + Vermicompost (on the basis of N content of FYM)	90862	296700	205839	3.21	133783	101731	264802	163071	2.73	114060	80664	219283	138619	2.65	105677

Table 4. Effect of irrigation methods and INM on Total losses of *rabi* onion kept for storability trials

Treatment	% Total Losses					
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	180 DAS
a) Irrigation methods						
I_1. Drip irrigation at alternate day as per ETc	2.20	16.12	18.93	22.35	26.92	30.32
I_2. Micro sprinkler irrigation at alternate day as per ETc	2.50	17.64	22.77	26.39	30.11	34.48
I_3. Surface irrigation at 50 mm CPE	3.94	19.60	28.009	29.911	33.021	38.683
SE^{+}_	0.031	0.039	0.087	0.068	0.070	0.098
CD at 5%	0.094	0.119	0.267	0.210	0.217	0.303
b) INM						
F_1. Control	2.67	17.07	22.25	25.13	29.31	33.28
F_2. RDF through NPK	2.96	18.07	23.16	26.34	29.78	34.15
F_3. AST (As per Soil Test)	3.60	19.72	25.36	27.90	31.68	35.53
F_4. RDF through NPK + FYM @ 10 t ha^{-1}	2.24	16.18	22.14	25.48	29.49	34.23
F_5. RDF through NPK + PMC (on the basis of N content of FYM)	3.19	18.77	24.02	27.01	30.38	35.50
F_6. RDF through NPK + Vermicompost (on the basis of N content of FYM)	2.62	16.90	22.49	25.44	29.47	34.19
SE^{+}_	0.143	0.489	0.642	0.722	0.829	0.954
CD at 5%	0.402	1.375	1.804	NS	NS	NS
Interaction	NS	NS	NS	NS	NS	NS
Mean	2.88	17.79	23.24	26.22	30.02	34.49

surface irrigation. The INM treatments had a negative balance for all the major nutrients in control treatment. This might be due to enhanced uptake of nutrients in drip and micro sprinkler irrigation methods. Further, INM also favoured uptake of nutrients. Similar results were also reported by Shinde *et al*. (2013).

Economics

The gross and net monetary returns and B:C ratio were highest under drip irrigation with RDF along with FYM @10t ha^{-1}, followed by micro sprinkler irrigation (Table 3) and lowest B:C ratio was observed under the surface irrigation treatments. The net extra income over control under drip irrigation was highest under the treatment RDF along with 10 t ha^{-1} FYM. Similar results were obtained by Basavraja *et al* (2007).

Storage Studies

The per cent total losses (Table 4) were significantly higher in the surface irrigation while lowest loss was in the treatment with drip irrigation. The INM treatment RDF + FYM and control treatments recorded the lower per centage of total losses as compared to AST (As per Soil Test) which recorded highest total losses of onion in storage at all the periods of storability. The per cent total losses in onion during storability were due to increase in water use efficiency and nutrient use efficiency. These results are in close agreement with those of Kadam (2012).

Conclusions

Planting of *rabi* onion under drip irrigation on flat beds and irrigation at alternate day at 100% ETc and application of RDF (100:50:50 kg N, P_2O_5 and K_2O ha^{-1}) with 10 t ha^{-1} FYM is recommended in medium deep soils of Maharashtra for higher yield, water saving, improved storability and returns.

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