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Influence of Fertilizer and Weed Management Practices on Yield, Economics and Post-harvest Soil Properties of Onion (*Allium cepa* L.)

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ABSTRACT

A field experiment was carried out during *rabi* season (September–March) of 2017–18 and 2018–19 at the experimental plot of RRTTS, OUAT, Keonjhar, Odisha to evaluate the nutrient and weed management practices on performance of onion. Fifteen treatmentswere designed in a split plot design. Among all the treatments, the maximum plant height was recorded in N_3W_4 (56.29 cm) which was closely followed by N_3W_3 (55.97 cm), number of leaves plant^{-1} was higher in N_3W_3 (12.47) significantly which was closely followed by N_2W_4 (12.33) and N_2W_3 (12.00) and maximum neck thickness was recorded in N_1W_2 (1.39 cm). Among yield parameters, the average bulb weight of onion ranges from 33.56 g (N_1W_2) to 87.6 g (N_2W_3) while, the highest bulb yields of onion (17.37 and 20.40 t ha^{-1}) was recorded for the treatment which to be exact was applied with pre-emergence application of pendimethalin @ 0.8 l ha^{-1} supplement with one hand weeding at 25 DAT with B:C ratio of 1.84 and 1.76 for the year 2017–18 and 2018–19 respectively. Similarly, the treatment combination of N_2W_3 i.e. application of 50% STBFR along with 50% FYM based on N requirement and pre-emergence application of pendimethalin @ 0.8 l ha^{-1}+onehand weeding at 25 DAT) was recorded the highest. The available nutrients like nitrogen, phosphorus, potash and sulphur content (284.67 kg ha^{-1}, 14.83 kg ha^{-1}, 97.43 kg ha^{-1} and 11.40 kg ha^{-1}) in the post-harvest soil was recorded highest with the treatment N_2W_3.

KEYWORDS: Nutrient, weed management, onion yield, economics, post-harvest soil properties

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1. INTRODUCTION

Onion (*Allium cepa* L.), belonging to the family of Alliaceae and possessing the chromosome number of 2n=16), is a bulb crop notable for its export oriented qualities (Patel et al., 2012). It is also consumed as fresh vegetable as well as spice crop grown for therapeutic, food and value for medicinal purposes. The members of this family contain sulphur compounds, which give them their characteristic piquancy and smell (Meher et al., 2016). The demand of onion has increased many folds recently owing to the fact that it is the only vegetable spice as it is a vital ingredient for both for the vegetarian and non-vegetarian diets (Nayak et al., 2016; Sahoo and Tripathy, 2019). Globally, after China, India produces about 16–17 mt of onion making it the world's second highest producer with the highest amount of area under onion cultivation in the whole worldandcontributes 21.5% share of onion production in the world but on the basis of productivity of onion crop, India ranks ninth in the world (Anonymous, 2019), so the productivity is not commendable owing to many factorsand weed and nutrient management are two major aspects among all (Mishra et al., 2021). In India, it is basically cultivated as a rabi crop(harvested during April-May) around 60% and successively 20% in *kharif* season (harvested during Oct-Nov) and another 20% in late kharif season (harvested in Jan-Feb) (Mishra et al., 2017).

Generally, yield loss of onion can be as high as 82.2% only because of weed infestation (Tewari et al., 2003, Patel et al., 2012). Weeds deprive the onion crop of space, light, nutrients, etc. thus increasing the cultivation costs (Hussain, 1983). For good onion production, good management practice for weeds is inevitable (Sahoo and Tripathy, 2019). Chemical control of weeds is not only easy and convenient to usebut also helps decrease manual weeding costs. However, to obtain maximum economic returns, judiciousapplication of herbicides along with manual weeding is also essential like other agrochemicals (Nayak et al., 2016; Sahoo and Tripathy, 2019)

Concerning fertilizer application, as a heavy feeder of mineral elements, onion responded positively to nitrogen and sulphur owing to yield and quality of bulbs (Vachhani and Patel, 1993; Nasreen et al., 2007; Panda and Mandal, 2018). Sulphur is essential for the production and synthesis of amino acids containing sulphur in onion which is favorable for a good growth in vegetative terms and development of the bulb (Anwar et al., 2001). Onion crop is responsive to fertilizers for the fact that its roots are shallow and their plant stand or population in the field is quite dense (Patel et al., 2012). Owing to awareness among the farmers regarding soil health hazard and safety of the environment, proper nutrient management is gaining momentum (Maji and Das, 2008). Keeping the above things in mind the current study was designed to determine the appropriate integrated approach for the application of synthetic fertilizers and herbicides for studying the economics and recording the yield for maximization of onion with minimal hazard to the soil health in Keonhar district of Odisha.

2. MATERIALS AND METHODS

2.1. Study site

The present field trial was carried out at the experimental plots of regional research and technology transfer station (RRTTS), OUAT, Keonjhar, Odisha, India during *rabi* season (September–March) of 2017–18 and 2018–19, respectively. This was located at 21° 55´ North latitude, 85° 37´ East longitude and at an elevation of 900 meters above the mean sea level. The parameters of the weather were observed in the field meant for experiments with maximum temperature (36.3 and 37.9°C) during May-2018 and 2019, minimum temperature (9.3 and 10.1°C) during January 2018 and 2019 and total annual rainfall of 1279.4 mm and 1539 mm with 65 and 81 numbers of rainy days during the year 2017–18 and 2018–19 respectively. The soil texture was loamy sand having pH of 6.4 and medium fertile soil with medium range of N and P (available Nitrogen 325 kg ha^{-1}, Phosphorus 18 kg ha^{-1}) however the available potash (K) is slightly lower than normal (106 kg ha^{-1}).

2.2. Experimental details

The experiment was designed with split plot technique having fifteen treatments viz., main plot nutrient management (N) practices: (N_1-Soil test based fertilizer recommendation(STBFR), N_2-50% STBFR+50% FYM based on N requirement, N_3-STBFR along with sulphur), and sub plots includes five weed management practices (W_1-Pre-emergence application of pendimethalin @ 0.8 l ha^{-1} , W_2-Pre-emergence application of oxyflurofen @ 0.2 l ha^{-1} , W_3-Pre-emergence application of pendimethalin @ 0.8 l ha^{-1} coupled with one manual weeding at 25 DAT, W_4- Pre-emergence application of oxyflurofen @ 0.2 l ha^{-1} along with one manual weeding at 25 DAT, W_5-Only one manual weeding at 25 DAT).

Eight weeks old onion seedlings of variety N-53 were transplantedby giving a row to row and plant to plant distance of 15×10 cm^2. To raise a good crop, the packages of practices as recommended were adopted equally to all the treatments except fertilizer and management practices for weeds which were carried out as per the treatments. Onion bulbs were harvested when tops started falling and the bulbs were matured. Treatment wise data were recorded from individual plots of each replication for growth parameters like plant height (cm), number of leaves $plant^{-1}$, yield parameters like average weight of bulb (g), neck thickness

(cm) and total yield of bulb (t ha^{-1}). After harvest, the samples of soil were collected from each treatment, dried and ground properly for further analysis by adopting standard protocols (Page et al., 1982, Panda, 2019).

2.3. Statistical analysis

Statistical analysis was then carried out on the recorded data (Gomez and Gomez, 1984). The comparisons among the treatments were analyzed at 5% level of significance made using t-test. On the basis of the prices prevailing in the markets of the local area, the economics were calculated and the cost of inputs for both the years 2017–18 and 2018–19 were calculated.

3. RESULTS AND DISCUSSION

3.1. Growth of onion

Results pertaining to growth and yield attributing parameters of onion of both the year (2017–18 and 2018–19) are presented in Table 1. Among the treatments, a significant variation was recorded on growth and yield parameters. Higher plant height was observed under the treatment where STBFR was applied along with sulphur (50.48 cm) and number of leaves (11.43) was found to be highest with application of 50% STBFR along with 50% FYM. However, the lowest value of plant height and number of leaves (37.82 cm and 9.31 respectively) were recorded with application of 100% STBFR only. Better growth of plant owing to the characters of plant height and number of leaves per plant was resulted with the application of 50% STBFR along with FYM and STBFR along with sulphur. This could be possible because of a combined doses of macro nutrients (N, P, K) with secondary nutrient like sulphur (S) at optimum level which leads to a better division of the growing cells, elongation of the cell, increased production of carbohydrate, constituent of the cell nucleus, protein synthesis in - vivo and translocation of photosynthesis (Nasreen et al., 2007).

So far as weed management practices were concerned, highest plant height was recorded under the treatment where pre emergence application of Pendimethalin @ 0.8 l ha^{-1} along with one hand weeding at 25 DAT was done (49.9 cm) which was closely followed by the treatment applied with pre-emergence application of Oxyflurofen @ 0.2 l ha^{-1} along with only one hand weeding at 25 DAT (49.04 cm). However, highest number of leaves was observed under the treatment applied with pre-emergence application of Oxyflurofen @ 0.2 l ha^{-1} along with one hand weeding at 25 DAT(11.6).

While observing the combination treatments, the highest plant height was recorded in N_3W_4 (56.29 cm) which was closely followed by N_3W_3 (55.97 cm) but significantly higher than rest other treatments. However, the lowest plant height was recorded in N_1W_5 (34.60 cm). The number of leaves plant $^{-1}$ was significantly maximum in N_3W_3 (12.47) which was closely followed by N_2W_4 (12.33) and N_2W_3 (12.00). However, the lowest number of leaves was observed under

Table 1: Effect of nutrient and weed management practices on growth and bulb yield of onion

Treatments	Plant height (cm)	No. of leaves $plant^{-1}$	Average bulb wt. (g)	Neck thickness (cm)	Bulb yield (t ha^{-1})
Nutrient management					
N_1	37.82	9.31	41.50	1.05	12.55
N_2	47.28	11.43	75.56	1.31	16.07
N_3	50.48	10.79	58.56	1.17	13.86
SEm±	0.36	0.10	0.43	0.04	0.13
N-CD (p=0.05)	1.06	0.30	1.26	0.03	0.36
Weed management					
W_1	45.4	10.91	53.69	1.13	13.36
W_2	41.36	10.02	51.49	1.10	12.42
W_3	49.04	11.60	66.95	1.23	16.09
W_4	49.90	11.16	62.74	1.23	14.95
W5	40.27	8.84	57.82	1.19	13.97
SEm±	0.47	0.13	0.56	0.05	0.16
W- CD (p=0.05)	1.37	0.39	1.62	0.04	0.47
Interaction effect					
N_1W_1	37.83	10.93	36.42	1.06	11.9
N_1W_2	36.39	8.47	33.56	0.91	11.3
N_1W_3	40.38	10.33	53.66	1.12	14.3
N_1W_4	39.89	9.33	44.42	1.08	13.2
N_1W_5	34.60	7.47	39.46	1.10	12.2
N_2W_1	44.63	11.20	69.86	1.22	14.9
N_2W_2	41.60	11.33	68.32	1.26	13.4
N_2W_3	50.77	12.00	87.6	1.39	18.9
N_2W_4	53.52	12.33	77.4	1.36	17.1
N_2W_5	45.90	10.27	74.6	1.32	16.1
N_3W_1	53.72	10.60	54.8	1.11	13.3
N_3W_2	46.09	10.27	52.6	1.14	12.6
N_3W_3	55.97	12.47	59.6	1.18	15.1
N_3W_4	56.29	11.80	66.4	1.25	14.7
N_3W_5	40.31	8.80	59.4	1.16	13.6
SEm±	0.81	0.23	0.97	0.09	0.28
N×W - CD (p=0.05)	2.37	0.67	2.81	0.07	0.81

N_1W_5 (7.47). This might be because of a synergistic effect of fertilizer and weed management practices that lead to a better rhizospheric biodiversity throughout the growth stages of crop (Patel et al., 2011).

Significant discrepancy was also recorded in different treatments for average bulb weight (g) and neck thickness (cm) of the bulb. The highest neck thickness (1.31 cm) was observed in the treatment applied with 50% STBFR+FYM which was significantly superior to rest other treatments. Yohannes et al. (2017) described that neck thickness is influenced significantly in greater values by the combined application of both organic and chemical fertilizers. Under weed management practices the highest neck thickness (1.23 cm) was observed under application of both the treatments (W_3- Pre-emergence application of Pendimethalin @ 0.8 l ha^{-1} along with one hand weeding at 25 DAT and W_4- Pre-emergence application of Oxyflurofen @ 0.2 l ha^{-1} along with one hand weeding at 25 DAT).

3.2. Bulb yield of onion

The highest average bulb yield (16.07 t ha^{-1}) was recorded under the nutrient management treatment with application of 50% STBFR along with FYM and 16.09 t ha^{-1}bulb yield was recorded under weed management practice with application of Oxyflurofen (PE) @ 0.2 l ha^{-1} + hand weeding at 25 DAT. The average bulb weight in onion varies from 33.56 (N_1W_2) to 87.6 (N_2W_3) and observed highest under the treatment N_2W_3 (87.6g) which was significantly superior to rest other treatments. Similar result also has been reported by Pradhan et al. (2015) in onion. Hand weeding and integrated herbicide application at critical stages of crop growth has proven to provide the optimum condition for crop growth and yield (Chandrika et al., 2009; Anjali et al., 2017). The total yield of onion was increased by 10.43% in N_3 (application STBFR along with Sulphur) than only application of soil test-based fertilizer recommendation(STBFR). Similar findings have also been reported by Mishra et al., 2017. Integrated application of organic and in-organics when compared with only soil test-based fertilizer recommendation produced higher yield. Total bulb yield was increased 28.04% in when soil was applied with 50% STBFR along with FYM than sole application of soil test-based fertilizer recommendation. Integrated use of both organic and inorganic fertilizers resulting the improvement in bulb yield can be attributed to a controlled release of soil nutrients via mineralization of organic manures (Prusty et al., 2019 and Mishra et al., 2021). The INM approach offers "win-win" opportunities for increasing crop yield and soil fertility while lowering environmental impact (Gnanasundari et al., 2022**)**. The beneficial effect of organic manures on yield might be due to additional supply of plant nutrients and improved physical and biological properties of soil (Gererufael et al., 2020).

The pre-emergence application of Pendimethalin @ 0.8 l ha^{-1} provided the highest onion bulb yields of 16.09 t ha^{-1} coupled with one manual weeding at 25 DAT, followed by pre-emergence application of Oxyfluorfen 0.2 l ha^{-1} supplemented with one hand weeding at 25 DAT (14. 95 t ha^{-1}). Reduced competition between crop and weed due to proper management practices of weed accelerating the onion crop's development and growth, resulting in obtaining higher bulb yield of onion (Patel et al., 2011, Mishra et al., 2021). However, a comparatively lesser yield was recorded from the treatment aided with only hand weeding suggesting unadvisable weed management practices as compared to other treatments in this experiment. This might be due topresences of more weed which interfered with growth and development of the crop and compete for the nutrients, moisture, light and space resulted less yield (Anjali et al., 2017; Paikra et al., 2022).

Application of both organic and chemical nutrient management coupled with pre-emergence application of pendimethalin at 0.8 l ha^{-1} supplemented with one hand weeding at 25 DAT during both the year 2017-18 and 2018-19 recoded significant increase in onion bulb yield (Table 2). The treatment combination of N_2W_3 (application of 50% STBFR along with 50% FYM based on N requirement and pre-emergence application of pendimethalin @ 0.8 l ha^{-1} supplemented with one hand weeding at 25 DAT) recorded highest bulb yield (17.37 and

Table 2: Effect of nutrient and weed management practices on economics of onion (*Allium cepa* L.)

Treatments (Interaction effect)	Gross cost ha^{-1} (₹)	Gross income ha^{-1} (₹)	Net income (₹)	B:C
N_1W_1	94132	118500	24369	1.28
N_1W_2	94007	113167	19160	1.22
N_1W_3	100301	142500	42200	1.44
N_1W_4	100176	131500	31325	1.33
N_1W_5	99976	121667	21691	1.23
$N2W_1$	98858	149167	50309	1.52
N_2W_2	98733	133667	34934	1.36
N_2W_3	105027	188834	83807	1.80
N_2W_4	104902	170500	65599	1.63
N_2W_5	104702	161167	56466	1.55
N_3W_1	96382	133000	36619	1.39
N_3W_2	96257	125667	29410	1.31
N_3W_3	102551	151334	48783	1.49
N_3W_4	102426	146500	44075	1.44
N_3W_5	102226	136334	34108	1.34

20.40 t/ha) followed by N_2W_4 (15.7 and 18.4 t ha^{-1}) and N_2W_5 (15.1 and 17.13 t ha^{-1}). However, the lowest bulb yield was observed in treatment where only STBFR was applied in nutrient management and only hand weed was done at 25 DAT in weed management practice (11.43 and 11.2 t ha^{-1}) followed by N_1W_5 and N_1W_1 during the year 2017–18 and 2018–19 respectively.

3.3. Economics

From the economics point of view,the gross cost per hectare was higher during the year 2018–19 due to increase in the cost of labour. So, though the maximum yield (20.40 t ha^{-1}) and gross income (₹ 204000) found in N_2W_3 during the year 2018-19in comparison to the year 2017–18 (gross income of ₹ 173667 from the yield of 17.37 t ha^{-1}) but, the highest B:C ratio was found in N_2W_3 in the year 2017–18 (1.84) than the year 2018–19 (1.76). From the pooled data it was clearly observed that maximum net return (₹ 83807) and B:C (1.8) ratio was recorded more under the treatment N_2W_3 and was followed by the treatment N_2W_4 (₹ 65599 and 1.63) respectively but superior to rest other treatments. However, minimum net profit (₹ 19160) and B:C (1.22) was recorded with N_1W_2 which was closely followed by N_1W_5. So, it was inferred that the application of Pendimethalin (PE) @ 0.81 ha^{-1} followed by one hand weeding at 25 DAT and fertilized the crop with 50% STBFR + FYM (Based on N requirement) combination found to be the most suitable, profitable and sustainable not only to secured the net return per unit cost but also improving the crop growth and yield by 50% reduction of chemical fertilizer. Plant requirements for inorganic nitrogenous fertilizers can be lowered using INM approaches, and a reduction in the usage of purchased fertilizers can result in significant cash savings for small farmers (Gnanasundari et al., 2022**)**.

3.4. Post-harvest soil Properties

The plant available nutrients content in soil after harvest of onion crop for both the years were estimated and the pooled data are presented in Table 3. Among the nutrient management practices maximum available N, P and K content in post-harvest soil were obtained (278.52 kg ha-^{1}, 14.09 kg ha-^{1}& 92.57 kg ha-^{1}respectively) under N_2 where 50% STBFR + FYM was applied followed by N_3(STBFR + Sulphur) which were significantly different with each other. It was mainly due to application of organic source (FYM) of nutrients in N_2which improved the post-harvest soil properties. But maximum soil available sulphur content of was recorded in N_3 (12.1 kg ha^{-1}) where sulphur was applied as an additional dose. However, the lowest nutrient content was observed in N_1(application of STBFR only). Combining different organic nutrient sources from organic manures, plant residues, biofertilizers, with chemical fertilizers would result in high nutrient use efficiency and improve the soil properties physically, biologically, and chemically by narrowing down the gap between nutrient removal and supply (Gnanasundari et al., 2022).

Table 3: Effect of nutrient and weed management practices of onion on post-harvest properties of soil

Treatments	Available soil nutrients			
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})
N_1	258.23	11.07	79.15	9.9
N_2	278.52	14.09	92.57	10.9
N_3	268.62	12.77	84.81	12.1
SEm±	4.83	0.73	2.30	0.86
N -CD (p=0.05)	13.9	0.21	6.63	0.25
W_1	266.37	12.41	83.72	10.69
W_2	263.60	12.19	82.46	10.50
W_3	273.38	13.30	89.07	11.48
W_4	270.84	12.84	86.84	11.20
W_5	268.09	12.48	85.44	10.94
SEm±	6.21	0.09	2.97	0.11
W- CD (p=0.05)	17.9	0.27	8.56	0.32
Interaction effect				
N_1W_1	256.97	11.00	77.97	9.80
N_1W_2	252.90	10.77	76.60	9.50
N_1W_3	262.73	11.73	81.77	10.27
N_1W_4	260.20	11.20	80.07	10.10
N_1W_5	258.33	10.67	79.33	10.00
N_2W_1	275.17	13.77	90.40	10.53
N_2W_2	273.57	13.50	88.67	10.47
N_2W_3	284.67	14.83	97.43	11.40
N_2W_4	281.47	14.33	94.00	11.13
N_2W_5	277.73	14.00	92.33	10.83
N_3W_1	266.97	12.47	82.80	11.73
N_3W_2	264.33	12.30	82.10	11.53
N_3W_3	272.73	13.33	88.00	12.77
N_3W_4	270.87	13.00	86.47	12.37
N_3W_5	268.20	12.77	84.67	12.00
SEm±	10.76	0.16	5.15	0.19
N×W- CD (p=0.05)	31.0	0.47	14.83	0.55

Among the weed management practices, maximum

available N, P, K and S content were recorded in W_3(277.38 kg ha^{-1}, 13.30 kg ha^{-1} , 89.07 kg ha^{-1} and 11.48 kg ha^{-1} respectively) where pendimethalin (PE) @ 0.8 l ha^{-1} was applied boosted with one hand weeding at 25 DAT that was significantly superior to rest other treatments. However, the lowest N, P , K and S content of (263.60 kg ha^{-1}, 12.19 kg ha^{-1} , 82.46 kg ha^{-1} and 10.50 kg ha^{-1} respectively) was obtained in W_2 where oxyflurofen @ 0.2 l ha^{-1} was applied as pre-emergence.

The treatment combination of N_2W_3 (application of 50% STBFR+50% FYM based on N requirement and pendimethalin (PE) @ 0.8 l ha^{-1} along with one hand weeding at 25 DAT recorded highest N, P, K and S content (284.67 kg ha^{-1}, 14.83 kg ha^{-1}, 97.43 kg ha^{-1} and 11.40 kg ha^{-1} respectively) followed by N_2W_4 (281.47 kg ha^{-1}, 14.33 kg ha^{-1} , 94 kg ha^{-1} and 11.13 kg ha^{-1} respectively) and N_2W_5 (277.73 kg ha^{-1}, 14 kg ha^{-1}, 92.33 kg ha^{-1} and 10.83 kg ha^{-1} respectively). However, the lowest nutrient content was observed in treatment N_1W_2 followed by N_1W_5 and N_1W_1. Efficient nutrient management package of practice along with proper weed management practices could lead to a better yield augmentation of onion under central table land agroclimatic zone of Odisha. Unavailability of essential nutrients during the growth of the crop and weed infestation affects crop growth and yield (Pradhan et al., 2015).

4. CONCLUSION

Application of 50% STBFR and 50% FYM based on N requirement along with weed management practice using pre-emergence application of pendimethalin @ 0.8 l ha^{-1}+hand weeding at 25 DAT recorded highest mean bulb yield of 18.89 t ha^{-1} with B:C of 1.80 followed by $N_2W_4$with yield and B:C of (17.05 t ha^{-1} and 1.63). The same treatment N_2W_3 also recorded highest available N, P, K and S content in the post-harvest soil of 284.67, 14.83, 97.43 kg ha^{-1} and 11.40 kg ha^{-1} respectively.

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