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Effect of integrated nutrient management on growth and yield of onion (*Allium cepa* L.) under Malwa Plateau of Madhya Pradesh

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Abstract
A field experiment was carried out to study the "Effect of integrated nutrient management on growth and yield of onion (*Allium cepa* L.) under Malwa Plateau of Madhya Pradesh" during Rabi seasons of 2020 and Rabi seasons of 2021 under irrigated conditions at Village –Ratadiya, Block – Ghattiya, Distt – Ujjain Madhya Pradesh. The experiment consist has 12 treatments with control like T_1-Control, T_2-100% inorganic RDF (N:P:K:S:Zn 120:60:80:40:05), T_3-Soil Test Based Fertilizer Recommendation (STV), T_4-75% RDF inorganic + 25% N through Vermicompost, T_5-75% RDF inorganic + 25% N through Poultry manure, T_6-75% RDF inorganic + 25% N through Neem cake, T_7-50% RDF inorganic + 50 N through Vermicompost, T_8-50% RDF inorganic + 50% N through Poultry manure, T_9-50% RDF inorganic + 50% N through Neem cake, T_{10}-100% N through vermicompost (VC) (7.0 t/ha), T_{11}-100% N through poultry manure (PM) (5.0 t/ha), T_{12}-100% N through Neem cake (NC) (3 t/ha) with three replications. The observation to be recorded for plant growth parameters such as plant height (cm) at 45 and 90 DAT and number of leaves 45 and 90 DAT. Plant yield parameters such as Average bulb weight (g), No. of scales per bulb, Bulb yield (q/ha), Bolting percentage and Harvest Index. The result revealed that the maximum plant height (cm) at 45 and 90 DAT (38.99 and 49.20 cm) and length of leaf (cm) 45 and 90 DAT (7.85 and 10.65). Plant yield parameters such as Average bulb weight (58.26 g), No. of scales per bulb (11.07), Bulb yield (382.85 q/ha), Bolting percentage (1.65) and Harvest Index (102.31) and the minimum was found under the Control.

Keywords: Onion, growth, bulb, organic and STV

Introduction

Onion (*Allium cepa*) is one of the most important commercial vegetables. The onion (*Allium cepa* L., from Latin *cepa* "onion"), is a vegetable crop that is the most widely cultivated species of the genus *Allium*. It is a close relatives to include the garlic, shallot, leek, scallionchive, and Chinese onion.

Onion is a cool season crop. However, it can be grown with a wide range of climatic conditions. It growing well under mild climate without extreme heat or cold or excessive rainfall. In areas where average annual rainfall exceed 75-100 cm in the monsoon periods. The optimal temperature range for onion crops is between 12.8 °C and 21 °C prior to bulbing, and between 15.5 °C and 25 °C during bulb growth. Early on, very low temperatures encourage bolting, but a sharp increase in temperature encourages early development in Rabi, which results in tiny bulbs.

Integrated nutrient management (INM) has been presented as a viable technique for tackling such difficulties, given the rising food needs of a growing human population and the need for an ecologically benign plan for sustainable agricultural growth. INM offers a diverse potential for improving plant performance and resource efficiency while also allowing for environmental and resource quality preservation. When compared to traditional approaches, INM boosts crop yields by 8-150 percent, increases water-use efficiency, and increases farmers' economic returns, all while enhancing grain quality and soil health and sustainability. Advanced INM methods significantly minimize reactive nitrogen losses and (Greenhouse Gas) emissions, according to model simulation and fate assessment.

Advanced INM procedures resulted in fewer chemical fertilizer inputs and, as a result, decreased environmental and human costs (such as intensity of land use, N consumption, reactive N losses, and green-house gas emissions) without sacrificing crop yields. INM practise might be an innovative and ecologically beneficial technique for global sustainable agriculture, according to strong and persuasive data (Wu, W., & Ma, B. (2015) [21]. For a healthy yield, onions need a lot of fertiliser and manure. Fertilizer needs, on the other hand, are determined by the soil type and crop type. Continuous use of inorganic fertilisers has a negative impact on soil health, resulting in decreased yields of poor quality. Organic materials are great for cultivation since they nourish the soil and help to maintain a healthy environment. Plants that have good soil have healthy plants. An organic soil filled with microorganisms and fungus gives nutrients to plants slowly, just as it does in nature. By adding organic nutrients to the soil and promoting the development of naturally existing beneficial organisms.

Plant nutrients come from the feed, supplements, medicine, and water that animals ingest. Using chicken dung as a fertiliser for crops might provide some or all of the plant's nutritional needs. Poultry dung is an excellent organic fertiliser source. It enhances the soil's physical properties, as well as nutrient absorption and crop yield (Ojeniyi *et al*., 2013; Mbah and Nnej 2011) [15, 11]. Organic additions, such as chicken manure, enhance soil qualities by increasing organic matter content, which has a stimulatory influence on structure and aggregate stability, resulting in improved aeration, soil response buffering, water holding capacity, and microbial activity (Bauer and Black 1992) [3]. Poultry 7 manure with a high concentration of organic carbon enhances soil organic matter and maintains a significant quantity of soil water, resulting in an increase in soil water content after application of the manure (Mohamed *et al*., 2010) [12].

Materials and Methods

A field experiment was carried out to study the "Effect of integrated nutrient management on growth and yield of onion (*Allium cepa* L.) under Malwa Plateau of Madhya Pradesh" during Rabi seasons of 2020 and Rabi seasons of 2021 under irrigated conditions at Village –Ratadiya, Block – Ghattiya, Distt – Ujjain Madhya Pradesh. The experiment consist has 12 treatments with control like T_1-Control, T_2-100% inorganic RDF (N: P: K: S: Zn 120:60:80:40:05), T_3-Soil Test Based Fertilizer Recommendation (STV), T_4-75% RDF inorganic + 25% N through Vermicompost, T_5-75% RDF inorganic + 25% N through Poultry manure, T_6-75% RDF inorganic + 25% N through Neem cake, T_7-50% RDF inorganic + 50 N through Vermicompost, T_8-50% RDF inorganic + 50% N through Poultry manure, T_9-50% RDF inorganic + 50% N through Neem cake, T_{10}-100% N through vermicompost (VC) (7.0 t/ha), T_{11}-100% N through poultry manure (PM) (5.0 t/ha), T_{12}-100% N through Neem cake (NC) (3 t/ha) with three replications. The observation to be recorded for plant growth parameters such as plant height (cm) at 45 and 90 DAT and number of leaves 45 and 90 DAT. Plant yield parameters such as Average bulb weight (g), No. of scales per bulb, Bulb yield (q/ha), Bolting percentage and Harvest Index.

Harvest index (%) was computed using the following formula:

$$\text{Harvest Index (H.I.)} = \frac{\text{Seed yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

$$\text{Bulb yield (q/ha)} = \frac{\text{Bulb yield (kg/plot)} \times 10{,}000}{\text{Net area of plot (m}^2\text{)} \times 100}$$

Result and Discussion

Plant Height (cm) at 45 and 90 DAT

In the application of fertilizers the treatment T_3 [Soil Test Based Fertilizer Recommendation (STV)] has showed maximum plant height at 45 DAT and 90 DAT. Followed by the treatment T_2 (100% inorganic RDF (N: P: K: S: Zn 120:60:80:40:05) and T_4 (75% RDF inorganic + 25% N through Vermicompost). While the minimum plant height at 45 DAT and 90 DAT, was recorded in treatment T_1 (Control). This result similar with the Pandy and Ekpo (1991) [16] who reported that highest plant height was obtained with highest nitrogen ha^{-1}. The higher nitrogen fertilizer concentration in NPS fertilizers, that encourages too much crop development and crop length, may be the cause of the variation in onion crop yields following enhanced NPS fertilization. Furthermore, the genetic composition of onion plants determines the height of the plants. Kitila *et al.,* (2022) [9]. A possible reason for crop failure could be high nitrogen use, which performs an important part in the production of amino acids, proteins, chlorophyll, and cells that support the growth of onions. This finding is consistent with studies by Nasreen *et al.,* (2007) [14], Gustafson (2010) [7], and Birhanu *et al.,* (2014) [4] that found that applying nitrogen fertilizer accelerated the vegetative growth of onions by increasing the rate of photosynthetic. When N is used, plants may grow taller because of improved vegetative growth, resulting in the benefits from the N supply increasing and causing the plant to use more cells to support growth and make protoplasm from carbohydrates.

Number of leaves per plant at 45 DAT and 90 DAT

In the application of fertilizers the treatment T_3 [Soil Test Based Fertilizer Recommendation (STV)] has showed maximum number of leaves per plant at 45 and 90 DAT. Followed by the treatment T_2 (100% inorganic RDF (N: P: K: S: Zn 120:60:80:40:05) and T_4 (75% RDF inorganic + 25% N through Vermicompost). While the minimum number of leaves per plant at 45 DAT and 90 DAT was recorded in treatment T_1 (Control). The quantity of onion leaves grows with the application of more NPKS fertilizer. There could be a mix of growth factors and insufficient nutrients causing the lower leaf yield at low fertilizer doses. With high NPKS fertilizer, there may be more leaves per plant since there are more macro- and micronutrients available to support the leaves' rapid growth. Fertilization with nitrogen and sulfur had the potential to boost plant nutrition intake through increasing nutrient uptake.

The current investigation's outcome aligns with the findings of Nasreen *et al.,* (2007) [14], who observed that an increase of 120 kg N ha^{-1} greatly increased the number of leaves in onion plants, and that an additional 160 kg N ha^{-1} increase in nitrogen supply tended to decrease it. According to Yohannes and Pant (2011) [23], fertilizer containing nitrogen greatly influenced how many leaves the onion plant produced. According to Uzma *et al.,* (2016) [19], garlic plants with low phosphorus fertilizer application rates had smaller leaves overall and in terms of both area and number of leaves. Muluneh (2016) [13] found that the combined application of 105:92:16.95 N: P_2O_5: S with a negligible amount of leaves from unfertilized plants resulted in an extremely high number of engraved leaves. One growth characteristic that nitrogen fertilizer may have a major impact on is the number of leaves.

There was a noticeable fluctuation in the effect of NPK fertilizer on the quantity of leaves. Applying NPK fertilizer results in more leaves, which can be explained by the minerals' influence on the various protein components needed for leaf formation. According to Abdissa *et al.*, (2011) [1], the rate at which the maximum leaf number is recorded varies depending on the growing environment and location.

Yield parameters of onions

Average bulb weight (g)

In the application of fertilizers the treatment T_3 [Soil Test Based Fertilizer Recommendation (STV)] has showed maximum average bulb weight. Followed by the treatment T_2 (100% inorganic RDF (N: P: K: S: Zn 120:60:80:40:05) and T_4 (75% RDF inorganic + 25% N through Vermicompost). While the minimum average bulb weight (g) was recorded in treatment T_1 (Control). The results of this study is consistent with the investigations conducted by Kokobe *et al.*, (2013) [10], who discovered that the impacts of N had a substantial impact on onion bulb weight. Shedeed *et al.*, (2014) [17] state that the rise in plant height, number of leaves produced, and leaf length in response to the greatest rate of N could be responsible for the increase in bulb weight.

Bulb yield (q/ha)

The treatment T_3 [Soil Test Based Fertilizer Recommendation (STV)] has showed maximum bulb yield. Followed by the treatment T_2 (100% inorganic RDF (N: P: K: S: Zn 120:60:80:40:05) and T_4 (75% RDF inorganic + 25% N through Vermicompost). While the minimum bulb yield (q/ha) was recorded in treatment T_1 (Control). The application of NPKS fertilizers may have increased bulb weight and size, which in turn may have increased photosynthesis. This might lead to improved growth and expansion of the vegetative growth overall, and eventually much higher carbohydrate content in the bulbs at maturity. The results of Tibebu *et al.*, (2014) [18], who saw high onion bulb yields in response to nitrogen application, are not consistent with this outcome. Additionally, Woldeyohannes *et al.*, (2007) [20] showed a consistent rise in onion bulb output as a result of raising the NPS's nitrogen levels from 0 to 100 kg N ha-1. This outcome was consistent with the research conducted by Bagali *et al.*, (2012) [2], which showed that increased amounts of inorganic fertilizers led to increased onion bulb yields. The application of N may have contributed to the rise in vegetative growth and enhanced assimilate production, which in turn led to an increase in bulb diameter and average bulb weight and an increase in marketable bulb yield (Girma 2011; Khan *et al.*, 2002; Nasreen *et al.*, 2007) [6, 14].

Bolting percentage

In the application of fertilizers the treatment T_3 [Soil Test Based Fertilizer Recommendation (STV)] has showed maximum bolting percentage *i.e.* 1.65%. Followed by the treatment T_2 (100% inorganic RDF (N: P: K: S: Zn 120:60:80:40:05) 1.49% and T_4 (75% RDF inorganic + 25% N through Vermicompost) 1.1.46%. While the minimum bolting percentage was recorded in treatment T_1 (Control) 0.62% respective.

No. of scales per bulb

In the application of fertilizers the treatment T_3 [Soil Test Based Fertilizer Recommendation (STV)] has showed maximum no of scales per bulb *i.e.* 11.07. Followed by the treatment T_2 (100% inorganic RDF (N: P: K: S: Zn 120:60:80:40:05) 10.83 and T_4 (75% RDF inorganic + 25% N through Vermicompost) 10.71. While the minimum no of scales per bulb was recorded in treatment T_1 (Control) 7.53 respective.

Harvest Index (%)

In the application of fertilizers the treatment T_3 [Soil Test Based Fertilizer Recommendation (STV)] has showed maximum harvest Index (%). Followed by the treatment T_2 (100% inorganic RDF (N: P: K: S: Zn 120:60:80:40:05) and T_4 (75% RDF inorganic + 25% N through Vermicompost). While the minimum harvest Index (%) was recorded in treatment T_1 (Control). The outcomes aligned with the findings of Gebretsadik and Dechassa (2016) [5], who reported that the highest harvest index was achieved with N application at 150 kg N ha−1, increasing harvest index relative to the control. In a similar vein, an increase in the rate of N application produced the greatest harvest index of 86% (Abdissa *et al.*, 2011) [1]. Nevertheless, the harvesting index of onions was greatly impacted by fertilizer application; the highest harvesting index was achieved at 30 t ha^{-1} and is statistically similar at 20 t ha^{-1}. Nonetheless, the control group yielded the lowest harvest index, which is statistically comparable when 10 t ha^{-1} is used. Girma (2011) [6] published similar results, showing that applying fertilizers at a rate of 0 to 20 t ha^{-1} boosted the harvest index by around 9%.

Table 1: Effect of integrated nutrient management on growth parameters of onion

Treatment	Plant height (cm) at 45			Plant height (cm) at 90			Number of leaves per plant at 45			Number of leaves per plant at 90		
	I year	II year	Pooled	I year	II year	Pooled	I year	II year	Pooled	I year	II year	Pooled
T_1	22.18	23.29	22.74	38.35	40.26	39.31	4.27	4.48	4.37	6.13	6.44	6.29
T_2	32.22	33.83	33.03	44.88	47.12	46.00	6.79	7.13	6.96	9.50	9.98	9.74
T_3	38.04	39.95	38.99	48.00	50.40	49.20	7.66	8.04	7.85	10.39	10.91	10.65
T_4	31.74	33.33	32.54	44.63	46.86	45.74	6.60	6.93	6.76	9.39	9.86	9.63
T_5	26.42	27.74	27.08	39.41	41.38	40.39	5.97	6.27	6.12	7.97	8.37	8.17
T_6	27.29	28.66	27.98	40.08	42.08	41.08	6.06	6.36	6.21	8.34	8.76	8.55
T_7	28.99	30.44	29.72	43.85	46.04	44.94	6.38	6.70	6.54	8.95	9.40	9.18
T_8	25.97	27.27	26.62	38.83	40.77	39.80	5.94	6.23	6.09	7.90	8.30	8.10
T_9	28.80	30.24	29.52	43.09	45.24	44.16	6.27	6.58	6.42	8.73	9.17	8.95
T_{10}	27.67	29.06	28.37	42.19	44.30	43.24	6.19	6.50	6.34	8.60	9.03	8.82
T_{11}	22.59	23.72	23.16	38.63	40.56	39.59	5.81	6.10	5.95	7.50	7.88	7.69
T_{12}	22.84	23.99	23.41	38.69	40.62	39.65	5.83	6.12	5.97	7.59	7.97	7.78
S.Em±	0.132	0.139	0.096	0.092	0.096	0.066	0.023	0.024	0.016	0.032	0.034	0.023
CD at 5%	0.423	0.444	0.273	0.293	0.308	0.189	0.072	0.076	0.047	0.103	0.108	0.066

Table 2: Effect of integrated nutrient management on yield parameters of onion

Treatment	Average bulb weight (g)			Bulb yield (q/ha)			Bolting percentage		
	I Year	II Year	Pooled	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	42.24	44.35	43.29	276.18	289.99	283.08	0.61	0.64	0.62
T_2	54.22	56.93	55.57	356.04	373.85	364.95	1.45	1.52	1.49
T_3	56.84	59.68	58.26	373.51	392.19	382.85	1.61	1.69	1.65
T_4	52.41	55.03	53.72	343.98	361.18	352.58	1.42	1.49	1.46
T_5	44.89	47.13	46.01	293.84	308.54	301.19	1.00	1.05	1.02
T_6	45.26	47.52	46.39	296.31	311.13	303.72	1.05	1.10	1.07
T_7	51.10	53.65	52.37	335.24	352.01	343.63	1.26	1.33	1.30
T_8	44.78	47.02	45.90	293.11	307.77	300.44	0.90	0.95	0.92
T_9	51.01	53.56	52.28	334.64	351.38	343.01	1.21	1.27	1.24
T_{10}	50.20	52.71	51.45	329.24	345.71	337.48	1.17	1.22	1.20
T_{11}	42.36	44.47	43.42	276.98	290.83	283.90	0.80	0.84	0.82
T_{12}	42.48	44.60	43.54	277.78	291.67	284.72	0.82	0.86	0.84
S.Em±	0.146	0.154	0.106	0.975	1.024	0.707	0.013	0.014	0.010
CD at 5%	0.467	0.491	0.302	3.115	3.271	2.014	0.043	0.045	0.028

Table 3: Effect of integrated nutrient management on yield parameters of onion

Treatment	No. of scales per bulb			Harvest Index		
	I Year	II Year	Pooled	I Year	II Year	Pooled
T_1	7.34	7.71	7.53	97.84	102.73	100.28
T_2	10.57	11.10	10.83	99.53	104.51	102.02
T_3	10.80	11.34	11.07	99.82	104.81	102.31
T_4	10.44	10.97	10.71	99.32	104.29	101.81
T_5	9.26	9.73	9.50	98.28	103.20	100.74
T_6	9.48	9.95	9.71	98.34	103.26	100.80
T_7	10.16	10.66	10.41	99.16	104.12	101.64
T_8	9.24	9.71	9.48	98.27	103.18	100.72
T_9	9.84	10.33	10.09	99.15	104.11	101.63
T_{10}	9.71	10.19	9.95	99.05	104.00	101.53
T_{11}	7.88	8.28	8.08	97.86	102.75	100.30
T_{12}	8.21	8.62	8.41	97.88	102.77	100.33
S.Em±	0.024	0.025	0.017	0.0285	0.0300	0.0207
CD at 5%	0.076	0.080	0.049	0.0911	0.0957	0.0589

Conclusion

For the two years of experiments, it is concluded that the In the application of fertilizers the treatment T_3 [Soil Test Based Fertilizer Recommendation (STV)] has showed maximum plant height at 45 DAT and 90 DAT, number of leaves per plant at 45 and 90 DAT, average bulb weight, bulb yield q/ha, harvest Index (%) and no of scales per bulb, followed by the treatment T_2 (100% inorganic RDF (N: P: K: S: Zn 120:60:80:40:05) and T_4 (75% RDF inorganic + 25% N through Vermicompost), While the minimum was recorded in treatment T_1 (Control).

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