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Farmers participatory assessments of weed control techniques in onion (*Allium cepa* L.) under the North West Plateau Zone of Odisha

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Abstract

A study on onion (*Allium cepa* L.) cultivation in Odisha investigated two weed control methods to address fluctuating production and low economic returns. The research compared the effectiveness of different herbicide applications on weed population, bulb yield and profitability. Application of oxyfluorfen @ 235 g/ha followed by one hand weeding 55 days after transplanting, proved to be the most effective strategy. This method resulted in a significantly lower weed density (7 weeds per square meter), a higher bulb yield (214 quintals per hectare) and a net income of ₹1,58,300 per hectare. In contrast, application of pendimethalin @ 750 g/ha followed by quizalofop ethyl at 50 g/ha at 20 days after transplanting recorded maximum weed count (10 weeds per square meter), a lower bulb yield (205 quintals per hectare) and net income of ₹1,48,500 per hectare. The study concluded that the oxyfluorfen treatment with one hand weeding is a more profitable and efficient weed management strategy for onion growers than traditional manual weeding.

Keywords: Onion bulb yield, profitability, weed control , weed index

Introduction

Onion (*Allium cepa* L.), the oldest and commercially cultivated vegetable in India. Onions are known for their high nutritional value, contain an abundance of essential nutrients such as vitamins (including vitamins C and B), minerals (such as potassium and manganese), and dietary fiber. Onions are also rich in phytochemicals, including flavonoids such as quercetin, which have antioxidant, anti-inflammatory, and various other health benefits (Sahoo *et al*., 2022). India is the second-largest onion producer, producing around 24 million metric tonnes per annum from an average area of 1.4 million hectares (Sharma *et al*., 2023). Since the country contributes around 25% of world onion production, it has a dominant position in global onion production. Over the three decades, onion productivity fluctuated between 9.9 tonnes/ha and 18.7

tonnes/ha increasing domestic market prices and impacting consumer budgets. Onion productivity differs between onion-growing states in India ranging from 6.15 tonnes/ha in Sikkim to 28.48 tonnes/ha in Haryana. The productivity remained constant at 56.45 tonnes/ha from 2017-18 to 2019-20. The productivity of onions in India has been inconsistent and has fluctuated over time. Apart from this, Indian onion has a high export value, it has been exported to over fifteen countries such as Bangladesh, Malaysia, the Arab world, Sri Lanka, Nepal, Indonesia, Saudi Arabia, etc. (Anonymous 2023).

The most destructive component in onion production is weeds. Onion cultivation faces persistent weed competition from the time of seed sowing until the completion of the vegetative growth and bulb development stage in the main field. Upadhyay *et al*., (2022) opined that undecomposed cow dung, when continuously incorporated as farmyard manure (FYM), has been observed to raise the population of weeds. The onion crop is therefore forced to compete with the weeds for nutrients, moisture in the soil, space, and light, which significantly lowers crop quality and bulb output. The excess weed population and its management costs further add to the problem (Goudar *et al*., 2021). Therefore, it is crucial to decompose the cow dung adequately before using it in the field. After mulching materials are removed in the nursery stage, monocot weeds may emerge alongside new onion seedlings, but these are generally manageable. Due to their rapid growth and towering height, these plants can be easily uprooted in their early stages. However, dicots are more numerous and have broad leaves that tend to cover the entire root zone of onion seedlings, creating an ideal environment for damping-off caused by *Pythium* spp. It is important to note that dicotyledons typically exhibit stronger growth than monocotyledons (Goudar *et al*., 2020). Therefore, their nutrient consumption must be higher than the amount of nutrients required for their counterparts. This is a challenge that onion growers must be prepared to face and overcome to ensure a successful harvest. Sahoo and Tripathy (2019) further stated that onions have a slow growth rate, small leaf size and a shallow root system that makes them highly vulnerable to weed competition during the early stages of growth. Frequent watering after high-dose fertilizer application facilitates its growth (Pachiyappan *et al*., 2022). In the absence of efficient weed management, crop development is hindered and onion bulb yields can drop sharply by as much as 80% in certain situations (Sahoo *et al*., 2019; Hembrom *et al*., 2023). Therefore, to ensure better bulb yield and economic returns, it is imperative to adopt judicious weed management practices.

To achieve the best bulb yield and economic returns in onion cultivation, a range of effective weed management practices are confidently employed. Dhananivetha *et al*., (2017) opined hand weeding, use of herbicides, integrated weed management (IWM), crop rotation, mulching, and inter-row cultivation are best suited management practices in onion. Hand weeding is a traditional method that is effective but time-consuming, labour-intensive and can be uneconomical in certain situations.

The application of herbicides are most feasible and economically viable method for weed management. According to Sahoo and Tripathy (2019), the best way to control weeds in onion crops is to use oxyfluorfen before planting and then manually weeding the crop 45 days after planting with 66.09% weed control efficiency. Crop free of weeds can be obtained by enforcing manual hand weeding 45 days after transplanting. Extensive research into the economics of this weed management practice has unequivocally shown that its implementation in farmers fields is highly economically viable. Numerous herbicide application schedules have been developed through research, but these findings need to be refined and validated in real-world farmer fields to ensure widespread adaptability and practical utility.

On-farm trials (OFTs) are essential for validating new agricultural technologies and ensuring their compatibility with existing farming systems (Choudhary *et al*., 2021). This approach is particularly critical for technologies requiring additional labor or inputs, as it helps to confirm their effectiveness and profitability under real-world conditions. By engaging farmers directly, OFTs facilitate the successful adoption of new technologies, ultimately aiming to increase farm income and productivity. The primary goal of this study was to authenticate the efficacy of specific herbicides, providing reliable information to growers to enhance their onion production and profitability.

Materials and methods

The experiment was conducted as on-farm testing (OFT) in Village Bisra (84.8670°E longitude and 22.2227°N latitude), located in the North West Plateau Zone of Odisha, under the Krishi Vigyan Kendra, Rourkela, Sundargarh, Odisha, during 2023-24. Birsa is one of the most prominent onion-growing areas with a wide range of weed diversity in onion, including both monocot and dicot weeds. The experimental site soil was a mixed grey and red laterite with a pH ranging from 5.5 to 6.9. The site receives an average annual rainfall of 1422.41 mm, and the temperature during the experiment ranged from a minimum of 13.81°C to a maximum of 40°C. The study was conducted using a Randomized Block Design (RBD) with two scheduled treatments involving pre- and post-emergence herbicides and compared with traditional hand weeding. It was replicated seven times in a farmer's field with an estimated area of one hectare. Statistical analysis of the data on weed management, yield attributes and yield was performed using Microsoft Excel (Windows 11). Treatment means were compared at 5% level of significance using the method described by Gomez and Gomez (1984).

The onion seeds of cv 'N-53' were treated with carbendazim + mancozeb before being sown in a meticulously prepared raised nursery bed. The onion seeds were treated, sown in nursery beds and covered with fine farmyard manure. Paddy straw mulching was used to promote germination. A preventive spray of chloropyriphos @ 2ml/l was applied to protect the nursery beds from termite infestation. Within a week, the onion seeds started to sprout and the flag leaves emerged from the mulching materials, indicating healthy seedling growth. The mulching materials were then carefully removed from the nursery beds to ensure the onion seedlings were not disturbed. Unwanted weeds germinated simultaneously with the onion seeds were also removed from the nursery beds, ensuring that the onion seedlings had the best possible chances to grow to their full potential with reduced competition for nutrients and other essentials during the nursery stage. To ensure the healthy growth of onion seedlings, the possibilities of damping off disease was proactively tackled with a preventative spray using a combination of carbendazim + mancozeb @ 2g/l and Streptocycline @ 1.5g/barrel.

To achieve high-quality growing media, both cultivator and rotavator were used to bring soil a fine tilth. The weed control methods consist of applying pendimethalin 750g/ha on one side of the plot and oxyfluorfen 235g/ha on the other side of the plot before planting was practised. Eight-week-old onion seedlings were uprooted with prior light irrigation to facilitate smooth uprooting and prevent root damage. The seedlings were then treated with carbendazim + mancozeb and planted in the main field with a precise spacing of 15 cm between the rows and 10 cm within the rows. The onion seeds were sown in November 2022 and after eight weeks in nursery beds, seedlings were transplanted in the main field during January 2023. To ensure maximum plant establishment, the seedlings were watered immediately after planting using the rose can. The post-emergence herbicide quizalofop ethyl was applied at a rate of 50g/ hectare exactly 20 days after planting, where pendimethalin was applied before planting. All other recommended practices were diligently implemented except for weed management.

A hand weeding was carried out after 55 days of transplanting in the plot where oxyfluorfen was applied before planting.

The weed data was collected after 70 days of transplanting. After harvesting, the onion bulbs were categorized as marketable (normal-sized and good-shaped bulbs) or unmarketable (small and elongated bulbs) based on their size and shape. The yield of bulbs from each plot was recorded in kg/plot and converted to tonnes/ha to determine the success rate of each treatment.

The effectiveness of weed management through weed control efficiency (WCE) was evaluated as per formula developed by Mani *et al*. (1973).

$$WCE\ (\%) = \frac{(WDc - WDt)}{WDc} \times 100$$

Where,

WCE: Weed control efficiency (%)

WDc: Weeds population in untreated/ weedy check plots, and

WDt: Weeds population in treated plots.

Weed Index (WI) was measured using the percentage reduction in crop yield caused by the presence of weeds in comparison to weed-free plots, as suggested by Choudhary *et al*., (2021). This index is expressed in percentages and can be calculated by using the following formula:

$$WI\ (\%) = \frac{(X - Y)}{X} \times 100$$

Where,

WI: Weed Index (%)

X: Crop yield from weed-free treated plots

Y: Crop yield from controlled plot.

The Weed Management Index (WMI) is an useful tool for measuring the effectiveness of different weed management options, and the following formula can estimate the Weed Management Index as in Kumar *et al*., (2022).

$$WMI = \frac{(Percentage\ crop\ yield\ over\ control)}{(Percentage\ control\ of\ weeds)}$$

The Agronomic Management Index (AMI) is a metric used to evaluate the effectiveness of different weed management treatments and is calculated using the following formula.

$$AMI = \frac{Percentage\ crop\ yield\ over\ control + Weed\ Management\ Index}{Weed\ Management\ Index}$$

The Integrated Weed Management Index (IWMI) is calculated by using the following formula.

$$IWMI = \frac{Weed\ Management\ Index + Agronomic\ Management\ Index}{2}$$

This study explored the economics of growing onions by contrasting the cultivation costs with the net profit and gross return. The cost of manpower wages during the period of experimentation and the cost of other inputs, which was regarded as the cost of cultivation. The following formula was used to assess the benefit-cost ratio for each therapy.

$$\text{Benefit-cost ratio} = \frac{Gross\ returns\ (Rs./ha)}{Cost\ of\ cultivation\ (Rs./ha)}$$

Results and discussion

Bulb yield

Determining the economic benefits for onion growers is critical to achieve better yields. In the current study, applying oxyfluorfen at a rate of 235g/ha and one-hand weeding 55 days after transplanting produced the highest marketable bulb yield (21.4 t/ha) compared to other weed management practices (Table 1). This method also resulted in a very less quantity of unmarketable onion bulbs (0.6 t/ha). On the other hand, applying pendimethalin at 750g/ha and quizalofop ethyl at 50g/ha at 20 (DAT)

produced a bulb yield of 20.5 t/ha. However, manual hand weeding resulted in the highest amount of unmarketable onion bulbs (1.6 t/ha). After comparing various weed management practices, it was found that applying oxyfluorfen at a rate of 235g/ha and weeding by hand 55 days after transplanting were the most effective methods for controlling weeds and that facilitated to harvest of an enhanced total bulb yield of 22.0 t/ha in onion. This weeds management practice resulted in a significant increase (12.24%) in bulb yield in comparison to the application of pendimethalin at 750g/ha and quizalofop ethyl at 50g/ha at 20 (DAT) which produced 9.18% higher bulb yield than the manual hand weeding.

The application of oxyfluorfen at a rate of 235g/ha, combined with one hand weeding 55 days after transplanting, resulted in the highest marketable and total bulb yield. This is because effective weed management allows healthy vegetative growth in onions. The quantity of bulb yield is directly related to the quality of leaves, which are converted into modified-scale leaves in the later stage of growth. Improving the modified scale leaves can lead to better development of onion bulbs, resulting in higher quality and weight. This, in turn, can increase onion production and productivity on a larger scale, ultimately leading to better economic returns. Tripathy *et al*., (2013) reported that oxyflurofen 23.5EC application at 2ml/l before planting, followed by one-hand weeding at 40-60 days after transplanting, significantly increased the yield of marketable and total bulbs. The herbicide mentioned above produced the highest marketable bulb yield of 18.23 t/ha and total bulb yield of 20.69 t/ha compared to the other treatments. Similarly, Ali *et al*., (2023) obtained lowest weed density of 1.7 weeds/square meter with a control efficiency of 84.5% in onion with oxyfluorfen, followed by pendimethalin with 2.0 weeds/square meter with a control efficiency of 81.7%. In comparison, the weedy check had 11.0 weeds per square meter. The weed-free plots had the highest average weight of onion bulbs (98.55 g) and bulb yield of 20.34 t/ha followed by pendimethalin with an average weight of 81.88 grams and bulb yield of 18.01 t/ha. The weedy check had an average weight of 45.17 grams and bulb yield of 7.89 t/ha. Sahoo and Tripathy (2019) reported that oxyfluorfen is an effective pre-emergence herbicide for controlling weeds in onions. This herbicide binds well to soil particles and remains stable, effectively preventing weed emergence and growth during the early stages of vegetative growth while promoting onion growth.

Weed management index

More than 30 weed species have been identified in onion fields, with *Cynodon dactylon* and *Cyperus rotundus* being the most prominent species that significantly limit bulb production. Main monocotyledonous weeds include *Cyperus difformis, Cyperus iria, Digitaria sanguinalis, Echinochloa colona, Eleusine indica* and *Paspalum scrobiculatum*. Predominant dicotyledonous species are *Alternanthera sessilis, Amaranthus spinosus, Amaranthus viridis, Cleome viscosa, Eclipta alba, Euphorbia hirta, Lantana camara, Mimosa pudica, Parthenium hysterophorus, Phyllanthus niruri, Physalis minima* and *Portulaca oleracea* as reported by Sankar *et al*., (2015).

Application of oxyfluorfen at 235g/ha and one manual weeding done at 55 days after transplanting drastically reduced the weed population (07 weeds/square meter) (Table 1). In contrast, using pendimethalin at 750g/ha followed by quizalofop ethyl at 50g/ha 20 days after transplanting (10 weeds/square meter) and manual hand weeding (28 weeds/square meter) recorded comparatively more weeds than the application of oxyfluorfen and manual hand weeding at 55 days after transplanting. Likewise, spraying of oxyfluorfen at 235g/ha followed by manual hand weeding exactly 55 days after transplanting achieved the highest (75%) weed control efficiency. This method outperformed pendimethalin application at a rate of 750g/ha, followed by quizalofop ethyl 50g/ha at 20 days after transplanting (achieving a rate of 64.2% weed control efficiency). On the other hand, manual hand weeding showed very

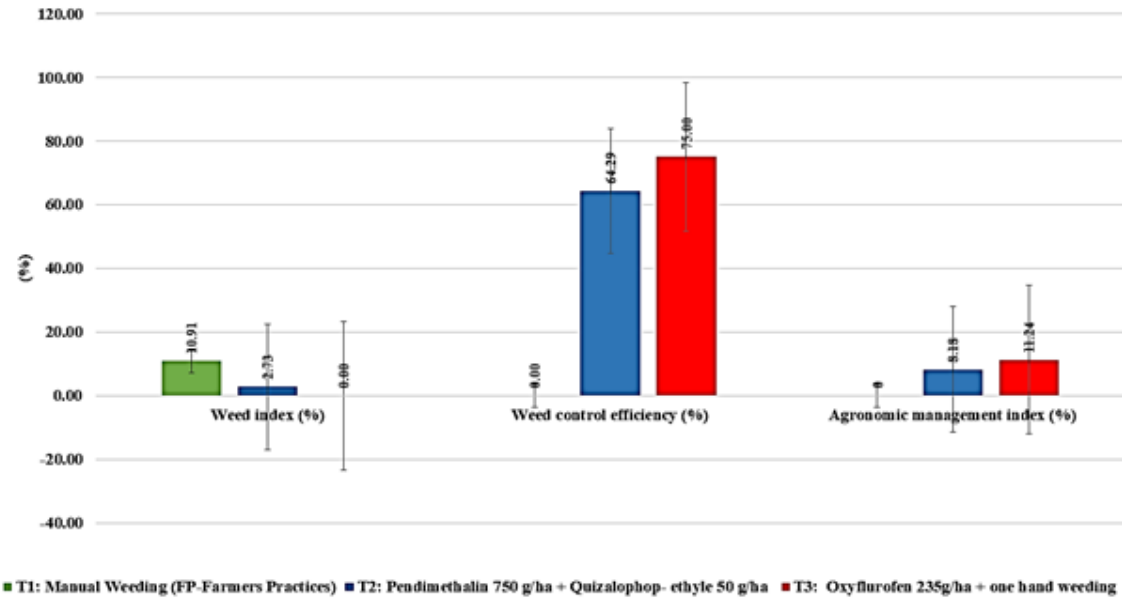

Fig.1. Impact of weed management practices on weed index, weed control efficiency and agronomic management index of onion in the North West Plateau Zone of Odisha.

low weed control efficiency. The application of oxyfluorfen at a rate of 235g/ha and one-hand weeding 55 days after transplanting had no weed index percentage, whereas manual weeding expressed showed the highest percentage of weed index (10.91%, Fig 1). Oxyfluorfen at 235g/ha and one-hand weeding 55 days after transplanting was superior to the other two weed management approaches in terms of the weed management index (0.16%), agronomic management index (11.24%) and integrated weed management index (5.70%).

An integrated approach using oxyflorofen at a rate of 235 g/ha, followed by a single manual hand weeding 55 days after transplanting, was identified as the most effective method for controlling weeds in onion crops. This strategy yielded superior weed management and integrated weed management indices, at 0.16% and 5.70% respectively, as detailed in Table 1 and Figure 1.

Profitability

In onion cultivation, removing weeds manually is a time-consuming and expensive process that can result in lower bulb yields. Therefore, it is more cost-effective to use appropriate herbicides to minimize cultivation costs. Table 2 shows comparison of costs for onion cultivation with and without herbicide use. Three weed control techniques were tested, including the sole application of oxyfluorfen, the sequential spray of pendimethalin followed by quizalofop ethyl and manual weeding. The maximum gross monetary return and net monetary return were reported at Rs. 256800/- per ha and Rs. 158300/- per ha, respectively, following the application of oxyfluorfen at a rate of 235g/ha and one-hand weeding 55 days after transplanting. With a benefit-cost ratio of 2.61, this weed control approach generated a monetary return that was 30.83% higher than the other two weed control strategies.

After careful consideration of the other two weed control methods, using two herbicides in a scheduled sequential spray resulted in higher input costs and is less effective than using oxyfluorfen alone. This approach also produces less bulb yield, resulting in lower economic returns and a lower benefit-to-cost ratio. On the other hand, manual weeding is more expensive and requires more manpower and time, which is not an effective approach

Table 1. Impact of weed management practices on onion bulb yield, weeds per square meter and weed management index

Weed management practices	Marketable bulb yield (q/ha)	Unmarketable bulb yield (q/ha)	Total bulb yield (q/ha)	% higher bulb yield over manual weeding	Weeds per m^2	Weed management index (%)	Integrated weed management index
T_1 : Manual weeding (FP-Farmers Practices)	180	16	196	-	28	-	-
T^2 : Pre-emergency application of pendimethalin 750 g/ha followed by quizalofop ethyl 50g/ha at 20 days after transplanting	205	09	214	9.18	10	0.14	4.16
T_3 : Soil application of oxyfluorfen 235 g/ha and one-hand weeding at 55 days after transplanting	214	06	220	12.24	07	0.16	5.70
SE(m)+	5.93	0.76	5.42	-	0.63	-	-
CD(P=0.05)	17.05	2.20	15.60	-	1.83	-	-
CV	1.88	4.77	1.69	-	3.02	-	

Table 2. Economics of different weed management practices for onion cv. N-53

Weed management practices	Cost of cultivation (Rs. /ha)	Gross monetary return (Rs. /ha)	Net monetary profit (Rs. /ha)	% higher monetary return over FP	B: C ratio
T1: Manual weeding (FP-Farmers Practices)	95000	216000	121000	-	2.27
T2:Pre-emergency application of pendimethalin 750 g/ha followed by quizalofop ethyl 50g/ha at 20 days after transplanting.	97500	246000	148500	22.73	2.52
T3: Soil application of oxyfluorfen 235 g/ha and one-hand weeding at 55 days after transplanting	98500	256800	158300	30.83	2.61
SE(m)+	1209	11987	6011	-	0.12
CD(P=0.05)	3479	34487	17293	-	0.34
CV	1	3	3	-	3.23

for managing weeds and getting optimum economic return from onion crop. Singh *et al*. (2016) recorded higher B:C ratio (2.31) with the application of oxyfluorfen + quizalofop ethyl.

Conclusion

Based on participatory evaluation with farmers, the most effective weed management strategy for onion fields involves applying oxyfluorfen at 235 g/ha along with one hand weeding at 55 days after transplanting. This approach not only maximizes bulb yield but also ensures a viable economic return. Its success in on-farm testing suggests a beneficial practice for onion growers. Hence, we suggest the promotion of a specific herbicide application followed by a hand weeding regimen. The objective is to improve weed control, thereby enhancing onion production and profitability. This approach should be implemented through frontline demonstrations to validate its efficacy and encourage broader adoption among farmers.

References

Ali K A, Salman K A & Ahmed A S 2023 Evaluation of the efficiency of some herbicides for controlling the weeds outgrowth in onion field (*Allium cepa* L.). Syrian J. Agric. Res. 10(1): 362–370

Anonymous 2023 State-wise area, production and productivity of onion. Horticultural Statistics at a Glance 2021, Horticulture Statistics Division, Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India, pp. 200–201, 336, 362, 364

Choudhary A K, Yadav D S, Sood P, Rahi S, Arya K, Thakur S K, Lal R, Kumar S, Sharma J, Dass A, Babu S, Bana R S, Rana D S, Kumar Adarsh, Rajpoot S K, Gupta G, Kumar Anil, M N H, Noorzai A U, Rajanna G A, Khan M H, Dua V K & Singh R 2021 Post-emergence herbicides for effective weed management, enhanced wheat productivity, profitability and quality in North-Western Himalayas: A participatory-mode technology development and dissemination. Sustainability 13: 5425

Gomez K A & Gomez A A 1984 Statistical Procedures in Agricultural Research. John Wiley, New York, pp. 20–29

Goudar P, Singh S, Kumar S, Rajanna G A & Bhat N V 2021 Competition ability of wild oat in different levels of fertilizers and wild oat management practices under controlled condition. Ann. Agric. Res. 42(2): 131–139

Goudar P, Singh S, Rajanna G A & Bhat N V 2020 Influence of nitrogen fertilizers on wheat yield and wild-oat competition — A review. Ann. Agric. Res. 41(4): 331–338

Hembrom P, Horo P, Baral S & Hembrom 2023 Effect of weed control methods on weeds, onion growth and yield. Indian J. Weed Sci. 55(1): 111–114

Kumar R M, Paramesh V, Yamanura Y & Rajanna G A 2022 Weeds of vineyard ecosystem and their management with selected broad spectrum herbicides. Indian J. Agric. Sci. 91(4): 531–536

Mani V S, Malla M L, Gautam K C & Das B 1973 Weed killing chemicals in potato cultivation. PANS 23: 17–18

Pachiyappan P, Kumar P, Reddy K V, Kumar K N R, Konduru S, Paramesh V, Rajanna G A, Shankarappa S K, Jaganathan D, Immanuel S, Kamble A L, Selvakumar R, Immanuelraj K T, Manogaran B R, Perumal A, Maruthanayagam U & Niranjan S 2022 Protected cultivation of horticultural crops as a livelihood opportunity in Western India: An economic assessment. Sustainability 14: 7430

Sahoo B B & Tripathy P 2019 Efficacy of herbicides against weed flora in onion (*Allium cepa* L.). J. Crop Weed 15(1): 158–163

Sahoo B B & Tripathy P 2019 Scheduling weed management practices for improving weed control efficiency and bulb yield in onion. Indian J. Weed Sci. 51(3): 308–311

Sahoo B B, Nayak B S, Mohanty S K & Khanda C M 2022 Significance of bio-fertilizer incorporation with customized organic manures to reduce inorganic nutrients on growth dynamics, bulb yield and economics of onion (*Allium cepa* L.) under the western undulating zone of Odisha. Vegetos 35: 923–934

Sankar V, Tripathy P C, Lawande K E & Ganeshamurthy A N 2015 Production technology. In: Krishna Kumar N K, Jai Gopal & Parthasarathy V A (Eds.) The Onion. ICAR-Directorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research, New Delhi

Sharma P, Udaya P & Bharati D 2023 The onion paradox — output falls, but so do prices. CRISIL Market Intelligence and Analytics, pp. 1–6

Singh S K, Shyam R, Chaudhary S & Yadav L M 2016 Weed management in onion. Indian J. Weed Sci. 48(2): 199–201

Tripathy P, Sahoo B B, Patel D & Dash D K 2013 Weed management studies in onion (*Allium cepa* L.). J. Crop Weed 9(2): 210–212

Upadhyay P K, Sen A, Singh Y, Singh R K, Prasad S K, Sankar A, Singh V K, Dutta S K, Kumar R, Rathore S S, Shekhawat K, Babu S, Singh R K, Kumar B, Dey A, Rajanna G A & Kulshekaran R 2022 Soil health, energy budget and rice productivity as influenced by cow products application with fertilizers under South Asian Eastern Indo-Gangetic Plains Zone. Front. Agron. 3: 758572.