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Assessment of integrated management practices against twisting disease in onion (*Allium cepa* L.) under farmer's field condition

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Abstract
Onion is the most commonly cultivated commercial vegetable and spice crop. Crop is being affected by various diseases and pests. Recent years, leaf twisting disease became a major diseases in onion and causing ranging from 20- 70%. On farm trials were conducted on "Assessment of Integrated management practices against twisting disease in Onion in the farmer's field conditions" of adopted villages of Vijayapura district during 2022-23 and 2023-24. The study was conducted by Krishi Vigyan Kendra, Indi (Vijayapura District), University of Agricultural Sciences, Dharwad, Karnataka. The on farm trials were laid out in eight farmer's field with two alternate technology options having integrated approaches (Technology Option 2: Module 1- DOGR, Rajgurunagar, Pune and Technology Option 2: Module 2-Adhoc recommendation UAS, Dharwad) which were compared with farmers practice (Technology Option 1). Two years pooled data indicated that technology option 3 (Soil application of Neem cake 5 q/ha+ *Trichoderma* + *Pseudomonas* 5 kg/ha with 100 kg of Farm Yard Manure (FYM)/ha + Seed treatment with Carbendazim @ 2 g/kg and seedling dip with *Pseudomonas florescens* @ 10 g/l + Foliar spraying of Boron @ 2 g/l at 20 DAT and Multi K @ 3 g/l at 40 DAT + Foliar spraying Hexaconazole 5 EC @ 0.1% and Fipronil 5 SG @ 1 ml/l at 30 DAT and 60 DAT.) recorded highest bulb yield (146.8 q/ha) followed by technology option 2 (Soil application of *Trichoderma* sp @ 2 kg multiplied with 100 kg of (FYM)/ha + Seed treatment with *Trichoderma* sp @ 6 g/kg seed + Seedling root dipping in solution of 0.25% Carbosulfan 25 EC + 0.1% Carbendazim 50 WP) + Foliar spray of insecticide Fipronil 5 SG @ 1 ml/l + Foliar spray of fungicide 0.1% Hexaconazole 5 EC or 0.1% Propiconazole 25 EC) which was reported bulb yield of 127.2 q/ha. Whereas, technology option 1 (Spraying with combinations of pesticides for three to four times) noticed lowest bulb yield of 93.4 q/ha. Least twisting percent was reported in technology option -3 (8.1%) followed by technology option -2 (12.9%). Highest twisting percent was recorded with technology option- 1 (38.2%). Highest gross returns (Rs. 3,92,000/ha), net returns (Rs. 1,96,258/ha) and B:C ratio (3.78) were reported with technology option – 3 followed by technology option -2 which was recorded gross returns, net return and B:C ratio of Rs. 2,55,430/ha, Rs. 1,71,484/ha and 3.04, respectively. Lowest values were recorded with technology option – 1. Integrated approaches like application neem cake, seed and seedling treatment with bio-agents and spray of pesticides were found effective in managing twisting disease in onion with increased bulb yield.

Keywords: Onion, twisting disease, integrated management, bulb yield and economics

1. Introduction
Onion is the most commonly cultivated vegetable around the world, (*Allium cepa* L. 2n = 16) belongs to the Alliaceae family and genus *Allium*. It is an important commercial vegetable and spice crop (Kyofa-Boamah *et al*., 2000) [19]. It is said to be native to Central Asia and Mediterranean region (McCollum, 1976) [23]. It is commonly known as "Queen of the kitchen" due to its high frequent use in one or the other culinary items, valued flavor, aroma, unique taste and medicinal properties (Griffiths *et al*., 2002) [11]. Onion is known for its flavor and pungency due to chief chemical constituent "Allylpropyl disulfide" (Ly *et al*., 2005) [21]. According to the global onion production data China considered as the leading producer, accounting for 24.92 percent of the total global production.

India followed closely behind with 22.83 percent of the production, while the USA secured the third position with 3.17 percent of the production. Onion ranked second in terms of cultivation area and third in productivity. In India, onion is cultivated in an area of 1.91 million hectares, resulting in a production of 31.27 million tones with productivity of 16.30 MT per hectare. In Karnataka area under cultivation is 0.23 million hectares, production is 2.77 million tones with productivity of 11.99 MT per hectare during the 2021-22 (Anon., 2022) [5]. However, demand for the onion has never been constant due to various hurdles in its production. Crop is being affected by various diseases and pests. Some of the diseases like purple blotch, downy mildew, *Stemphylium* blight, basal rot, storage rots and now recently twisting disease. Prior to 1997, leaf twisting disease was minor disease in onion crop, but in the recent years this is one of major diseases. Onion twister, a disease of rainy season onion, was first reported near Zaria, north Nigeria, in 1969 (Ebenebe, 1980) [9]. Kuruppu (1999) [18] reported the disease on shallot onions, *Allium cepa* var. ascalonicum, that caused yield losses of 20 to 30 percent in Kalpitiya Peninsula in the North Western Province of Sri Lanka. Both seed and bulb crop were infected with disease severity of 20-30 and 50-70 percent, respectively. In the recent years, twister disease has become epidemic on onion crop in coastal tract and other onion growing districts in Karnataka. This disease vernacularly in Srilanka called as Disco, in Indonesia seven whorl and in Karnataka as Haavu suruli roga/Tirupu roga. In Karnataka, leaf twisting disease complex severity has varied from 7.9 to 52.4 percent (Anon., 2005) [3]. Patil *et al*. (2017) [28] reported twisting of leaves, stem and bulbs of onion which has caused serious threat to cultivation and loss was estimated to extent of 40-60 percent. Both seed and bulb crops are infected with disease severity of 20-30 percent and 50-70 percent respectively (Anon., 2011) [4].

The twisting disease was earlier considered caused by co-infection *of Colletotrichum gloeosporioides*, *Fusarium oxysporum* f. sp. cepae and *Meloidogyne* spp. (Patil *et al*., 2018) [29]. However, its etiology studied in detail and found to be caused by *Colletotrichum gloeosporioides* and *Fusarium oxysporum* f. sp. cepae. The disease caused huge shortage in onion supply across the country due to severe twister disease outbreak both in Karnataka and Maharashtra during Kharif 2019 and 2020. This resulted in sudden decline in onion supply and acute shortage of seeds also due to failure of seed crops. In view of significant negative impact of onion twister disease on its production and supply, the current trial was initiated with an objective to know the effect integrated approaches like combination of insecticides, fungicides, bio-agents and bio-pesticides on disease development and yield and yield attributing characteristics of onion during kharif season of 2022-23 and 2023-24.

2. Material and Methods

On farm trials were conducted on “Assessment of Integrated management practices against twisting disease in Onion in the farmer’s field conditions” of adopted villages of Vijayapura district during Kharif season under irrigated situation during 2022-23 and 2023-24. The study was conducted by Krishi Vigyan Kendra, Indi (Vijayapura District), University of Agricultural Sciences, Dharwad, Karnataka. Experiment site was selected having previous season onion crop with heavy twister incidence in the adopted villages of district. The soil type of the trial was black soil. The on farm trials were laid out in eight farmer’s field with two alternate technology options which were compared with farmers practice. Details of Technology options are given in Table 1. Seeds of Panchaganga brand (var. NIFAD Selection) were sown following the broadcasting method uniformly on nursery beds to raise seedlings. The details of implementation of on farm trial are shown in Table 2. The details of cultivation practices followed in field of trials are presented in Table 3.

2.1 Land preparation

Main field was ploughed for two times and levelled followed by rotovator and brought soil to good tilth condition. Required quantity of farm yard manure was mixed into main field four weeks before transplanting.

2.2 Nursery and Sowing

Manures and fertilizers were applied to nursery bed as per the package of practices. Seeds were treated as per the treatments and broadcasted treated seeds in nursery beds.

2.3 Transplanting of Onion seedlings and Crop Maintenance in Main field

Thirty to forty five days old seedlings used for transplantation to main field. As per the treatments, seedlings were treated with bio agents. Seedlings were transplanted with spacing of 15 x 10 cm. Fertilizers were applied as basal dose and top dresses as per the package of practices. Details of crop maintenance given in the table 3.

2.4 Observations recorded

2.4.1 Recording of observations on yield and yield attributing characters

2.4.1.1 Neck Length (mm)

Randomly selected twenty-five onion plants from a harvested stalk of each treatment were measured for their neck length and then the mean value was calculated.

2.4.1.2 Diameter of the bulb (mm)

Twenty-five randomly selected bulbs harvested from each treatment and diameter was measured individually and the mean of all twenty five samples were calculated.

2.4.1.3 Average single bulb weight (g)

Average single bulb weight was measured on electronic balance by taking the mean weight of five bulbs randomly selected in three location from each treatment.

2.4.1.4 Total bulb yield per hectare (q/ha)

Five subplots were marked with size of 5 x 5 m and total bulb obtained from the individual marked plot was weighed after curing and expressed recorded weight bulb yield of each treatment in kilograms per plot. Total bulb yield obtained from the individual plot was used to calculate bulb yield per hectare and expressed in quintals.

2.5.1 Economical analysis

The cost of cultivation of each treatment was derived by taking into account each input, unit price and total inputs consumed including labour wages until harvesting of the crop. Based on the total yield obtained and gross returns and net returns were calculated.

Gross returns (Rs./ha) = Total values of the produce = Bulb yield per ha × Bulb price

Net returns (Rs./ha) = Gross returns (Rs./ha) – Cost of cultivation (Rs./ha)

2.5.1.1 Benefit-cost ratio (B: C ratio)
To know the rate of return per rupee invested, the benefit-cost ratio was calculated using the below formula.

$$BCR = \frac{\text{Gross returns (Rs./ha)}}{\text{Cost of cultivation (Rs./ha)}}$$

2.5.3 Observation on Diseases
The data regarding the occurrence of twisting diseases were collected 40 Days after transplanting (DAT), 80 DAT and at harvest and expressed in percent.

3. Result and Discussion
Different management practices influenced the growth, yield and yield parameters, twisting disease incidence and economics of Onion cultivation. Among all the technology Options tested, Integrated approaches both Module 1 (DOGR, Rajgurunagar, Pune) and Module 2 (Adhoc recommendation, University of Agriultural Sciences, Dharwad) were better than farmers practices in both the years 2022-23and 2023-24.

3.1 Neck length (mm)
Different variations were recorded in terms of neck length (mm) influenced by different management practices against onion twister disease (Table 4) in both 2022-23 and 2023-24 years. In the year 2022-23, the maximum neck length (68.4 mm) was recorded in farmers practice treatment. Whereas, Module 2 (Adhoc recommendation, University of Agriultural Sciences, Dharwad) recorded minimum neck length (52.6 mm) followed by Module 1(DOGR, Rajgurunagar, Pune) which was recorded neck lengths of 64.5 mm. Similar results were obtained during 2023-24 also. Pooled data also indicated that, Lowest neck length (50.6 mm) was reported with treatment receiving integrated approach Module 2 (Adhoc recommendation, University of Agricultural Sciences, Dharwad) followed by Module 1 (DOGR, Rajgurunagar, Pune). The highest neck length (63.6 mm) was reported with farmers practice treatment. Increased neck length was due to more incidence of twisting disease in case technology option 1 (Farmers Practice). Technology Option 3 with lesser twisting disease reported least neck length. Barbosa *et al*. (2001) [7] reported that combined usage of T. viride + P. fluorescens decreased neck length of onion, Artificial inoculations of onion seedlings with *Colletotrichum gloeosporioides*, *Fusarium oxysporum*, *Meloidogyne* spp. alone and in combinations expressed twister disease symptoms of elongated neck with slender bulb, which were twisted abnormally (Patil *et al.*, 2018) [29].

3.2 Bulb diameter (mm)
The results showed that there was a considerable variation in yield and yield attributing parameters between the different management practices against twisting disease of onion (Table 4). In the first year, results revealed that technology option 3 (Module 2) had maximum bulb diameter (13.8 cm) followed by technology option 2 (Module 1) which was reported bulb diameter of 12.6 cm, The least bulb diameter of 9.8 cm was obtained in the technology option 1 (farmers practice). Data of second year study and pooled also showed similar trend of data of the year 2022-23. Naguleswaran *et al*. (2014) [25] reported the bulb treatment together with foliar application of *Trichoderma viride*, performed very well by enhancing bulb diameter (29.64 mm), circumference of the bulb (76.06 mm).

3.3 Single Bulb weight (g)
An improvement in yield attributing characters certainly had improvement in yield. Different management practices tested against onion twister had varying effects on single bulb weight. Variation was observed in bulb weight (g) of onion in different management practices (Table 4). The highest single bulb weight (80.3 g) was recorded in the technology option 3 (Module 2). Whereas, Technology option 2 (Module 1) recorded bulb weight of 63.3 g. The lowest bulb weight (48.9 g) was recorded in technology option 1 (Farmers practice). Barbosa *et al*. (2001) [7] reported that combined usage of *Trichoderma viride* + *Pseudomonas fluorescens* improved yield attributing parameters like bulb diameter, and bulb weight under field conditions. This is mainly due to the fast growth of *Trichoderma* competing with disease-causing fungi for food and space, as well as producing mycotoxin substances against the soil or foliar pathogens as enhancing growth and vigour of seedlings.

3.4 Yield (kg/plot)
Different management practices showed variation in Onion (kg/plot) yield (Table 4). The highest yield (34.2 kg/25 m^2) was recorded in the technology option 3 (Module 2) followed by technology option 2 (Module 1) which was reported yield of 30.4 kg/m^2.The lowest bulb yield (22.8 kg/25 m^2) was recorded in technology option 1 (Farmer practice). Similar trend of 2022-23 was observed during 2023-24 also with respect to single bulb weight. Pooled data also followed same trend of results of both 2022-23 and 2023-24 seasons. A similar result was obtained by Singh (2002) [30], who recorded a significant reduction in Alternaria blight of sunflower by foliar application of carbendazim + mancozeb with enhanced grain yield. Spray of Propiconazole also reported a significant reduction in disease incidence and improvement in yield and yield-related parameters. Combined usage of *T. viride* + *P. fluorescens* as foliage treatment was found most effective in reducing the twister disease and increasing yield. It is also well documented that the interaction of *Trichoderma* with the plant enhances disease resistance (Harman *et al*., 2004; Gajera *et al*., 2013) [14, 10]. The improvement in bulb diameter, size index and yield attributes were mainly due to the ability of *P. fluorescens* to trigger defence in the host and enhance the uptake of insoluble or fixed phosphorus from the soil (Gupta and Gupta, 2013) [12].

3.5 Total bulb yield per hectare (t/ha)
Assessment of different management practices against onion twister showed its impact on bulb yield with variations among the technology options (Table 4). In the year 2022-23, technology option 3 (Soil application of Neem cake 5 q/ha+ *Trichoderma* + *Pseudomonas* 5 kg/ha with 100 kg of Farm Yard Manure (FYM)/ha + Seed treatment with Carbendazim @ 2 g/kg and seedling dip with *Pseudomonas florescens* @ 10 g/l + Foliar spraying of Boron @ 2 g/l at 20 DAT and Multi K @ 3 g/l at 40 DAT + Foliar spraying Hexaconazole 5 EC @ 0.1% and Fipronil 5 SG @ 1 ml/l at 30 DAT and 60 DAT) had highest total onion bulb yield of 136.8 q/ha. Next best technology option was technology option 2 (Soil application of *Trichoderma* sp @ 2 kg multiplied with 100 kg of farm yard manure (FYM)/ha + Seed treatment with *Trichoderma* sp @ 6 g/kg seed + Seedling root dipping in solution of 0.25% Carbosulfan 25 EC + 0.1% Carbendazim 50 WP) + Foliar spray of insecticide Fipronil 5 SG @ 1 ml/l at 30 DAT+ Foliar spray of fungicide 0.1% Hexaconazole 5 EC or 0.1% Propiconazole 25 EC) which was

recorded total bulb yield of 121.5 q/ha. Whereas, Technology option 1 (Farmer practice - Spraying with combinations of pesticides for three to four times) recorded lowest total bulb yield of 91.3 q/ha. During 2023-24 also, technology option -3 recorded highest total onion bulb yield of 156.8 q/ha followed by technology option -2 which was reported total bulb yield of 132.8 q/ha. The lowest total onion bulb yield of 95.4 q/ha was recorded with Technology option -1.

Pooled data also showed similar trend of results of 2022-23 and 2023-24. Pooled data indicated that, there was 57.2% increase in bulb yield in technology option-3 over technology option -1 whereas technology option -2 recorded 36.2% increase in bulb yield over technology option -1. The treatment consisting of Carbendazim 12% + Mancozeb 63% 75 WP recorded the highest yield of 28.28 t/ha followed by treatment of Propiconazole 25 SC and *T. viride* + *P. fluorescens*, which recorded 27.45 t/ha and 26.89 t/ha respectively (Manthesha *et al.*, 2023) [22]. The lowest yield was observed in treatment receiving chemicals *viz.*, Flusilazole 12.5% + Carbendazim 25% 37.5 SE (18.28 t/ha) followed by Tebuconazole 25.9 SC (18.84 t/ha) which were on par with each other. The untreated control recorded bulb yield of 14.70 t/ha. The results of the experiments on the management of onion twister disease concluded that spraying with Carbendazim 12% + Mancozeb 25% 75 WP or Propiconazole 25 EC or a mixture of *T. viride* + *P. fluorescens* (1%) will reduce the onion twister disease with the highest cost-benefit ratio. The combined application of *Trichoderma* + *Pseudomonas* was the new intervention included in this study and was found effective in terms of reduced disease incidence, enhanced yield, yield-related parameters. These findings are slightly consistent with those of Hinduja *et al*. (2021) [16], who recorded the highest yield of 15.30 q/acre and lesser disease intensity (27.8%) in combined application *Pseudomonas fluorescens* + *Trichoderma viride* + silkworm excreta for the management of purple blotch of onion. Naguleswaran *et al*. (2014) [25] in a field trial showed that bulb treatment combined with foliar spray of *T. viride* increased onion production up to 130.7 Mt/ha with a negligible disease incidence (1.08%) against onion leaf twisting disease. Thus, it is evident beyond doubt that application of combi fungicides and combined bio-control agents' mixture both were promising in reducing the onion twister disease incidence and shall form the recommendations against the disease for adoption by the farmers. Anam Choudhary and Shabbir Ashaf (2019) [2] reported that, application of *T. harzianum* + Neem cake effectively enhanced growth and yield parameters and minimised the dry root rot in Mungbean.

3.6 Effect of Integrated disease management practices on percent twisting disease incidence and Percent control of twisting disease

There were variations in percent twisting incidence and percent control of twisting disease as influenced by different management practices in both years 2022-23 and 2023-24 at 40 DAT, 80 DAT and at harvest (Table 5). Results of 2022-23 at 40 DAT revealed that, lesser incidence of twisting disease (11.25%) was reported in technology option -3. Technology option -2 was recorded 14.83% of twisting disease incidence. Whereas, Technology option 1 recorded highest percent incidence of twisting disease (30.16%). Similar trend of percent twisting incidence was noticed during 2023-24 also. Pooled data also showed similar trend of results of 2022-23 and 2023-24. Technology option -3 reported lesser incidence of twisting disease (8.50%) followed by technology option -2 which was reported 13.63% of twisting disease incidence. The highest percent of twisting disease incidence (30.20%) was recorded with Technology option 1. Lina *et al*., (2018) [18] reported incidence of twisting disease in onion ranged from 30.4% to 94.9%. Similar observations were reported by Anon (2005) [3], Hill (2008) [15], Alberto and Aquino (2010) [1] and Nargund *et al*. (2013) [26] working with twister disease of onion in different region. The result was harmonious with Bajad (2017) [6] recorded onion anthracnose disease in the two districts, Latur and Osmanabad, showed disease intensity 28.08 to 50.00 percent and 41.38 to 60.00 percent, respectively. Duong *et al*., (2014) [8] reported that application neem cake + T. harzianum inhibited the plant parasitic nematode *Meloidogyne* spp. and four phytopathogenic fungi: *Rhizoctonia solani*, *Sclerotium rolfsii*, *Colletotrichum* spp. and *Phytopthora capsici* in Black pepper.

With respect to percent control of twisting disease during 2022-23, technology option -3 was recorded highest percent control of twisting disease (62.40%) over technology option I. Whereas, technology option 2 had 50.82% control of twisting disease. In the year 2023-24, there was 81.02% control of twisting disease with technology option -3 followed by technology option -2 which was recorded 58.93% control of twisting disease over technology option 1. Similar trend of results obtained at 40 DAT was recorded at 80 DAT and at harvest stage also. Gyempeh *et al*., (2015) [13] report the field symptoms of the disease during the survey were curling, twisting, chlorosis of leaves, and abnormal elongation of the neck. Species within the genus *Trichoderma*, have been evaluated in several areas and found to be very potent in the control of target pathogens (Verma *et al.*, 2007) [31]. In the study, *T. asperellum* was evaluated for its antagonistic activity against *C. gloeosporioides*, the causal agent of onion twister disease in Ghana. The bio-agent was able to inhibit the mycelial growth of the pathogen by more than 60 percent and nearly totally inhibited spore formation by the pathogen. Similar studies have shown that *T. asperellum* was very effective against *Fusarium oxysporum*. An *in vitro* study conducted Patil and Nargund (2016) [27] revealed that triazole fungicides significantly showed typical fungicidal activity against onion twister pathogens even at lower concentrations (0.10%). These results indicate that triazoles, a class of fungicides, are becoming increasingly important in the control of plant diseases under their mode of action. The triazole fungicides inhibit one specific enzyme, C14- demethylase, which plays a role in sterol production. These sterols are needed for membrane structure and the development of functional cell walls of fungi. Thus triazole fungicides result in abnormal fungal growth and eventually death of fungi (Mueller, 2006) [24]. Similar results have been reported by Kumar *et al*., (2018) [17] in onion. Spray of hexaconazole after 30 and 60 days of planting was found effective in management of pathogens and increase growth parameters. These findings were similar to Nargund *et al.*, (2013) [26].

3.7 Effect of Integrated disease management practices on economics of Onion cultivation

The economics of onion cultivation was influenced by different disease management practices in both years of study (Table 6). During 2022-23, the highest gross returns (Rs. 2,48,250/ha), net income (Rs. 1,64,465/ha) and B:C ratio (2.98) were recorded in technology option 3 followed by Technology option -2 which has recorded gross returns of Rs. 2,18,700/ha, net returns of Rs. 1,35,340/ha) and B:C ratio of 2.63. The lowest gross returns (Rs. 1, 46,000/ha), net returns (Rs. 60,220/ha) and B: C ratio (1.71) with technology option -1. During second year also followed similar trend in grass returns, net returns and B: C ratio. Two years pooled data indicated that, technology option 3 recorded higher gross income (Rs. 3,20,125/ha), net income (Rs. 1,96,258/ha) and B:C ratio (3.78) followed by Technology option 2, which has recorded gross returns of Rs. 2,55,430/ha, net returns of Rs. 1,71,484/ha) and B:C ratio of 3.04. The lowest gross returns (Rs. 1,68,400/ha), net returns (Rs. 85,398/ha) and B:C ratio (2.04) with technology option I. The cost of cultivation of onion was not varied much among different technology options. Pertaining to percent increase in net returns over technology option -1 during first year of study, there was 42.73% increase in net returns with technology option -3 followed by Technology option -2, which has recorded 33.15% increase in net returns. Increase in grass returns and net returns were due to higher bulb yield intern due to increased growth and yield parameters. Improved growth and yield parameters were due to reduction in twisting disease incidence. Manthesha *et al*., (2023) [22] reported a benefit to cost ratio of various fungicides and bio-agents imposed they ranged from 3.03 to 5.74. Highest B;C ratio was recorded in treatment Carbendazim 12% + Mancozeb 25% 75 WP (5.74) followed by treatment of Propiconazole 25 EC (5.59) and treatment of *T. viride* + *P. fluorescens* (5.46) against control plot (3.03).

Table 1: Details of Technology Interventions of On Farm Trials

Technological Options	Details of Technology	Source of Technology
TO - 1	Spraying with mixture of pesticides (Imidacloprid 17.8% SL, Fipronil5 SG, Monocrotophos 36% SL, Hexaconazole 5% EC, Spraying alone or in combinations for three to four times)	Farmer's Practice
TO - 2	• Soil application of *Trichoderma* sp @ 2 kg multiplied with 100 kg of farm yard manure (FYM)/ha. • Seed treatment with *Trichoderma* sp @ 6 g/kg seed • Seedling root dipping (0.25% carbosulfan 25 EC + 0.1% carbendazim 50 WP) • Foliar spray of insecticide Fipronil 5 SG @ 1 ml/l • Foliar spray of fungicide Hexaconazole 5 EC or Propiconazole 25 EC (0.1%).	Module 1- DOGR, Rajgurunagar, Pune
TO - 3	• Soil application of Neem cake 5 q/ha+ *Trichoderma* + *Pseudomonas* 5 kg/ha with 100 kg of Farm Yard Manure (FYM)/ha • Seed treatment with Carbendazim @ 2 g/kg and seedling dip with *Pseudomonas florescens* @ 10 g/l • Foliar spraying of Boron @ 2 g/l at 20 DAT and Multi K @ 3 g/l at 40 DAT. • Foliar spraying Hexaconazole 5 EC @ 0.1% and Fipronil 5 SG @ 1 ml/l at 30 DAT and 60 DAT.	Module 2- Adhoc recommendation UAS, Dharwad

Table 2: Details of the On Farm Trials implemented during 2022-23 and 2023-24

S. No	Particulars	2022-23	2023-24
1	Area under Each treatments (ha)	0.10	0.10
2	Area under each trial (ha)	0.30	0.30
3	No. of farmers/trials	04	8
4	Total area of trials	1.2	2.4
5	Villages	Ahirsang, Gotyal and Vibhutihalli	Ahirsang, Gotyal, Vibhutihalli, Indi
6	Taluk	Indi, Chadchan and Sindagi	Indi, Chadchan and Sindagi
7	Soil Type	Black soil	Black soil
8	Cropping Situation	Irrigated	Irrigated
9	Date of sowing	1st and 2nd week of July	2nd and 3rd week of July
10	Date of Transplanting	2nd and 3rd week of August	3rd and 4th week of August
11	Date of Harvest	1st and 2nd week of December	1st and 2nd week of December

Table 3: Details of the common cultivation practices adopted for on farm trials of Onion crop

S. No	Particulars	2022-23	2023-24
1	Variety	Pancha Ganga	Pancha Ganga
2	Seed rate (kg/ha)	10 kg/ha	10 kg/ha
3	Farm Yard Manure	30 t/ha	30 t/ha
4	Method cultivation	Transplanted	Transplanted
5	Age of seedlings for transplanting	30-45 days old seedlings	30-45 days old seeedlings
6	Spacing	15 x10 cm	15 x 10 cm
7	Fertilizer application	125:75:125 kg NPK/ha	125:75:125 kg NPK/ha
8	Irrigation intervals	Weekly intervals and stopped irrigation 15 days before harvest of the crop	Weekly intervals and stopped irrigation 15 days before harvest of the crop
9	Weeding operation	Manual weeding (2 times at 20 and 40 DAT)	Manual weeding (2 times at 20 and 40 DAT)
10	Harvesting	Manually pulling	Manually pulling
11	Detopping operation	Detopping done by Manually	Detopping done by Manually

Table 4: Effect of Integrated disease management practice on growth and yield parameters of Onion

Technology Options	Neck length (mm)			Bulb diameter (cm)			Single bulb weight (g)			Bulb yield per plot (Kg/25 m^2)			Total Bulb Yield (q/ha)		
	2022	2023	Pooled data	2022	2023	Pooled data	2022	2023	Pooled data	2022	2023	Pooled data	2022	2023	Pooled data
TO- 1	58.7	68.4	63.6	9.8	11.5	10.7	48.9	50.6	49.8	22.8	23.9	23.4	91.3	95.4	93.4
TO- 2	54.8	64.5	59.7	12.6	15.6	14.1	63.3	73.4	68.4	30.4	33.2	31.8	121.5	132.8	127.2
TO- 3	48.6	52.6	50.6	13.8	18.2	16.0	80.3	99.1	89.7	34.2	39.2	36.7	136.8	156.8	146.8

Table 5: Effect of integrated disease management practice on twisting disease of Onion

Technology Options	% Twisting disease incidence									% Control of Twisting disease								
	At 40 DAT			At 80 DAT			at harvest			at 40 DAT			at 80 DAT			at harvest		
	2022	2023	Pooled data	2022	2023	Pooled data	2022	2023	Pooled data	2022	2023	Pooled data	2022	2023	Pooled data	2022	2023	Pooled data
TO- 1	30.2	30.2	30.2	35.8	38.2	37.0	42.6	30.9	36.8	-	-	-	-	-	-	-	-	
TO- 2	14.8	12.4	13.6	12.5	10.2	11.4	13.7	12.2	12.9	50.8	58.9	54.9	65.1	73.3	69.2	67.8	60.5	64.9
TO- 3	11.3	5.7	8.5	8.5	4.5	6.5	9.7	6.5	8.1	62.7	81.0	71.9	76.3	88.2	82.4	77.2	78.9	77.9

Table 6: Effect of Integrated disease management practice on economics of Onion cultivation.

Technology Options	Gross Returns (Rs/ha)			COC (Rs/ha)			Net Returns (Rs/ha)			B:C Ratio)			% increase in Net Returns		
	2022	2023	Pooled data	2022	2023	Pooled data	2022	2023	Pooled data	2022	2023	Pooled data	2022	2023	Pooled data
TO- 1	1,46,000	1,90,800	1,68,400	85,425	80,580	83,0,03	60,575	1,10,220	85,398	1.71	2.37	2.04	-	-	
TO- 2	2,18,700	2,92,160	2,55,430	83,073	84,820	83,947	1,35,628	2,07,340	1,71,484	2.63	3.44	3.04	33.15	39.20	36.18
TO- 3	2,48,250	3,92,000	3,20,125	83,785	85,550	84,668	1,64,465	2,28,050	1,96,258	2.98	4.58	3.78	42.73	64.36	53.55

4. Concussion

The technology option 3 (Soil application of Neem cake 5 q/ha+ *Trichoderma* + *Pseudomonas* 5 kg/ha with 100 kg of FYM/ha + Seed treatment with Carbendazim @ 2 g/kg and seedling dip with *Pseudomonas florescens* @ 10 g/l + Foliar spraying of Boron @ 2 g/l at 20 DAT and Multi K @ 3 g/l at 40 DAT + Foliar spraying Hexaconazole 5 EC @ 0.1% and Fipronil 5 SG @ 1 ml/l at 30 DAT and 60 DAT) were found effective in controlling twisting disease in onion and recorded highest bulb yield, gross returns, net return and B:C ratio. Technology option -2 (Soil application of *Trichoderma* sp @ 2 kg multiplied with 100 kg of FYM/ha + Seed treatment with *Trichoderma* sp @ 6 g/kg seed + Seedling root dipping in solution of 0.25% Carbosulfan 25 EC + 0.1% Carbendazim 50 WP) + Foliar spray of insecticide Fipronil 5 SG @ 1 ml/l + Foliar spray of fungicide 0.1% Hexaconazole 5 EC or 0.1% Propiconazole 25 EC) was next best technology option. Integrated approaches like application neem cake, seed and seedling treatment with bio-agents and spray of pesticides were found effective in managing twisting disease in onion with increased bulb yield and economics.

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6. References

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