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On-farm evaluation of integrated nutrient and pest management in *Cicer arietinum* L.

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Abstract

Chickpea (*Cicer arietinum* L.) is the world's third most important pulse crop. In chickpea, wilt caused by *Fusarium oxysporum* f. sp. *ciceri* is one of the major production constraints. On-farm demonstration on use of *Trichoderma viride*, PSB and *Rhizobium* was conducted during rabi (Nov-Jan) 2006 in Machanapally village, Ranga Reddy district, AP, India. At harvest, data on wilt incidence yield and related parameters were recorded. In T1, where seeds were treated with PSB+*Rhizobium*+*T. viride* followed by soil application of *T. viride*+PSB+*Rhizobium* after 30 DAS (mixed with 200 kg of FYM), wilt incidence was 4.5% and yield was 0.995 $t.ha^{-1}$. In T2, where carbendazim was applied as seed treatment followed by the soil application of recommended doses of NPK, wilt incidence was 8.3% with a yield of 1.2 $t.ha^{-1}$. In T3, where seeds were treated as in T1 and NPK was applied to soil as in T2, wilt incidence was 3.3% and crop yield was 1.13 t. ha^{-1}. Highest plant dry mass (25.5 $g.plant^{-1}$) and number of effective nodules (6.3 $plant^{-1}$) were recorded in T3. To conclude, integrated nutrient and disease management is an ideal approach for chickpea cultivation.

Keywords: *Trichoderma viride*, Wilt incidence, PSB, *Rhizobium*, Chickpea

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the world's third most important pulse crop, after dry beans (*Phaseolus vulgaris* L.) and dry peas (*Pisum sativum* L.) [1]. India ranked first in terms of chickpea production and consumption in the world. About 65% of global area with 68 % of global production of chickpea is contributed by India [2]. Low yield of chickpea is attributed to its susceptibility to several fungal, bacterial and viral diseases. Among the diseases affecting chickpea, wilt caused by *Fusarium oxysporum* f. sp. *ciceris* is the most serious and causes annual loss of 10% in yield [3]. It is an important pest in chickpea growing areas of the world particularly in United States, India, Spain and in the Mediterranean region [4, 5]. The pathogen is both seed and soil borne. Drenching with fungicides is very expensive and impractical. *F. oxysporum* survive as mycelium and chlamydospores in seed and soil, and also on infected crop residues, roots and stem tissue buried in the soil for up to 6 years and yield losses of up to 60% may occur under favourable conditions [6].Therefore, integrated management strategies are the only solution to maintain plant health. These strategies should includes minimum use of chemicals for checking the pathogen population, encouragement of beneficial biological agents to reduce pathogen inoculum, modification of cultural practices and use of resistant varieties [7]. In the light of certain limitations in the management of wilt disease, the use of antagonists is considered as one of the safe approach.

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MATERIALS AND METHODS

Microorganisms

Trichoderma viride (TV01) strain was procured from Tamilnadu Agricultural University (TNAU), Coimbatore, India and mass multiplied in yeast molasses medium containing 3.0% molasses and 0.5% yeast. Five days old culture broth was formulated in talc with 1% carboxy methyl cellulose (CMC) to maintain 2 x10^8 CFU/g. *Bacillus megatherium* var *phosphaticum* (phosphate solubilising bacterium) and *Rhizobium* sp. NGT-634(1) were obtained from Regional Biofertilizer Development Centre (RBDC), Nagpur. Pikovskaya's broth containing glucose - 10 g; $Ca_3(PO_4)_2$; $(NH_4)_2SO_4$ - 0.5 g; KC1 - 0.2 g; $MgSO_4$ - 0. I g; MnSO4 – traces; $FeSO_4$ – trace; Yeast Extract - 0.5 g; distilled water – 1.0 L and Yeast extract mannitol agar media containing yeast extract -1.0 g; mannitol-10.0 g; K_2HPO_4-0.5, $MgSO_4$- 0.2; Nacl - 0.1; distilled water; 1.0 L were used for the mass multiplication of PSB and *Rhizobium* respectively. The pH of the lignite was adjusted to 7.0 by adding 10.0 g of $CaCO_3$ kg^{-1}. The cultures were formulated in pre-sterilized lignite (min 2 x 10^8 CFU/g) separately and stored in low density polyethylene milky white bags.

Field design

In order to evaluate the efficacy of integrated use of biological and chemical components for the effective management of wilt disease in chickpea, the experiment was conducted during the post rainy season at farmer's field at Machanapally village (N 17.320 and E78.134) in Ranga Reddy district of Andhra Pradesh, India during *rabi* 2006-07. Chickpea cultivar GG-2 was used during the experiment with a seed rate of 60 kg ha^{-1}. The crop was sown during third week of November at a spacing of 30 x 10 cm. The experiment was conducted in completely randomized block design (RBD) replicated six times. One insecticide (Chloropyrifos) spray was given at pod formation stage to control pod borers. Total rainfall during the crop stand was recorded as 24.9 mm.

Seed treatment and basal application

The field experiment comprised of 4 treatments *viz.,* T1: PSB 10g + *Rhizobium* sp 10.0 g and *Trichoderma viride* 5.0 g kg^{-1} seed as seed dresser followed by PSB 7.5 kg, *Rhizobium* sp 7.5 kg and *T. viride* 6.25 kg in 500 kg farm yard manure (FYM) were applied as basal application at 30 DAS over ha^{-1}. In the second treatment (T2) Carbendazim 3.0 g kg^{-1} seed was used as seed dresser and 20 kg N and 35 kg P_2O_5 and 20 kg murate of potash (MOP) as basal application over ha^{-1}. Entire dose of N, P and K was applied as basal. In T3 treatment, the seeds were treated as in T1 followed by basal application as in T2 treatment. Untreated check (T4) was maintained where seeds were sown without any amendments.

The percent field emergence was calculated based on formula number of seeds sown/ number of seeds germinated x 100. The wilt incidence was recorded at 15 days interval till harvest. After maturity 10 plants were pulled out with entire root system intact from each plot carefully. The roots were washed with water and plant dry weight and grain yield (kg/ha) were recorded. In each plot, number of diseased plants were counted and percent disease incidence in each treatment was calculated using the following formula., number of infected plants/ total number of plants X 100.

RESULTS

Field study

Highest field emergence of 93.8% was observed in T2 where chemical fungicide was used as seed dresser. Whereas, combined application of T3 bio-and chemical agents of seeds in T3 showed 93.1% seedling emergence which was statistically (P>0.05) on par with T2. In T1, 92.7% seed germination was observed where completely bio-inputs were applied. In case of untreated plot only 75% seedling emergence was noted (Table 1).

Lowest 3.3% of wilt incidence was recorded in T3 followed by T1 with 4.5%. In case of T2 the disease incidence was recorded as 8.3% and highest incidence (18.1%) was recorded in control plot plants (Table 1). Highest plant dry mass of 25.5 g. $plant^{-1}$was recorded in T3 plants followed by T2 plants with 24.8 g. $plant^{-1}$. T1 plants, showed 23.1 g of dry weight, where as control (T4) plants had a dry mass of 21.5 g. $plant^{-1}$. Similarly, highest number of effective nodules (6.30/ plant) were observed in T3 plants, whereas, T1 plants showed 6.12 nodules/ plant. In T2 and T4, the number of effective nodules was 4.27 and 3.66/ plant respectively that significantly decreased by 50% compared to other treatments.

Grain weight was recorded across the treatments by taking 100 numbers of grains as reference. T3 treated plants, recorded highest grain weight of 13.48 g, which was on par with T2 (13.25 g). In case of T1 and T4, 11.37 g, 11.12 g of grain weight was recorded respectively. Highest yield of 1290 kg. ha^{-1} was recorded in T2 where chemical fungicide was applied. Similarly, in T3 yield was 1130 kg. ha^{-1}. In T1 and T4 yield was 995 and 820 kg. ha^{-1} respectively.

Table 1. Details of field emergence and percent of wilt disease incidence in chickpea

Treatments	Field emergence (%)	Wilt incidence (%)	Cost of cultivation* (in $ USD)
T1	92.7	4.5	20.5
T2	93.8	8.3	19.5
T3	93.1	3.3	18.5
T4	75.0	18.1	-

*Cost incurred for seed treatment and soil application only.

Table 2. Details of field emergence and percent of wilt disease incidence in chickpea

Treatments	Total dry mass. $plant^{-1}$ (g)	No. of effective nodules. $plant^{-1}$	Grain weight (g)	Yield. ha^{-1}(kg)
T1	23.1 ($\pm$2.12)	6.12 ($\pm$0.56)	11.37	995
T2	24.8 ($\pm$2.28)	4.27 ($\pm$0.39)	13.25	1290
T3	25.5 ($\pm$2.35)	6.30 ($\pm$0.58)	13.48	1130
T4	21.5 ($\pm$1.98)	3.66 ($\pm$0.33)	11.12	820

Values in parentheses are $\pm$SD

DISCUSSION

In the current study, seed treatment with PSB, *Rhizobium* and *Trichoderma viride*, followed by soil application of inorganic nitrogen, phosphorus and potash can be used to control wilt incidence effectively and increased chickpea yield significantly over other treatments. The consortia of microbes like PSB, *Rhizobium* and *T. viride* does the plant growth promotion *via* 'P' solubilization, nitrogen fixation and biological control of wilt disease incidence. PSB is a strong organic acids (citric, gluconic, fumaric, succinic, 2-keto gluconic) producer that solubilises the complex P in soil and converts them into assimilatory form. Proton excretion and phosphatase enzyme production were also reported earlier by [8]. *Rhizobium* is a symbiotic nitrogen fixer also known to produce plant growth promoting compounds like IAA, GA and ACC deaminase [9]. The possible suppression of wilt incidence in chickpea is due to antagonistic activity by *T. viride* by producing various extracellular enzymes which play an important role in biological control [10]. Menendez and Godeas [11] reported a biocontrol study of *Trichoderma harzianum* against *Sclerotinia sclerotiorum* a soil-borne plant pathogen attacking many economically important crops, such as, soybean. metabolites produced by *Trichoderma* spp. (*e.g.* volatiles, extracellular enzymes and/or antibiotics) were considered to be the probable elements involved in antibiosis [12].

Fusarium oxysporum f. sp. *ciceris* is one of the yield limiting factors of chickpea across the world. The losses caused by wilt varied from 10% to 100% [13] depending upon the agro-climatic conditions. Due to the soil borne nature of the disease, use of chemicals in controlling the chickpea wilt is hardly successful. Hence, the economical and feasible approach would be either to search for resistant source or resort of biological control.

Field emergence of seedlings in the current study was highest in T2 which was on par with T3 where a combination of bio- and chemical agents was applied. The high rate of germination in T3 could be due to the presence of PSB and *Rhizobium* and *T. viride* strains, which might have produced phytohormones and other growth promoting substances. The present results are supported with the observations that *Trichoderma* spp. produces growth factors that increased the rate of seed germination [14]. Earlier workers also observed enhanced seed germination with treatment of *Trichoderma* spp. in several host pathogen systems [15, 16, 17]. It is evident that, the enhancement in yield by the application of bio- and chemical fertilizer as, reflected on the total pods yield and its physical quality. Similar results were reported earlier by Jha and Mathur [18] Hegde et al., [19] and Selvakumari et al., [20].

Germinating seeds and roots of seedlings are known to excrete exudates, and they are the major force behind spermosphere and rhizosphere activities of soil borne plant pathogens as well as those associated microorganisms [21]. Competitive native microflora can also be a major deterrent in the effectiveness of biological agents applied to the soil and to seeds. Papavizas [22] reported that *T. harzianum* did not survive well in the rhizosphere of bean and pea seedlings when the seeds were coated with the conidia and when the conidia were applied directly to the soil one day before planting. Hubbard et al., [23] also found *Trichoderma* species to be susceptible to competition from *Pseudomonas* sp. when used as a biological control agent in natural soil. Soil application of *Trichoderma* + FYM before sowing in addition to seed treatment provided better control of wilt in chickpea [24].

Seed treatment with *T. viride,* PSB and *Rhizobium* has effectively controlled the incidence of wilt in T3 treatment which could be due to the antifungal potential of *Trichoderma* spp. that has been well documented [16, 25]. *T. harzianum* has been proved effective against several soil and seed borne diseases [15-17]. Poddar et al. [17] reported that rhizosphere isolate of *T. harzianum* decreased wilt incidence in chickpea. The reduction in disease incidence in T3 also lead to higher yield which was on par with T2 where complete chemical fungicide was applied. Though high yield was recorded in T2, the cost of cultivation is significantly less for T3, more importantly; contamination by chemical fungicides is relatively less (data not shown) and the average grain weight was recorded high in T3 treatment due to the constant supply of nutrients to the plants through out the cropping season.

CONCLUSION

It could be concluded that, the combined application of bio-agents with chemical fertilizer for chickpea resulted in reduced wilt incidence with better yield, high grain weight and relatively toxic free grains.

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