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New Innovative Technology for Producing Exemplary Yields of Garlic and Onion

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Abstract

Garlic and onion are multipurpose vegetable, spices, medicinal and cosmetic crops, where productivity and cost of produce fluctuate noticeable year after year; for onion within the year as a result of many crops harvests in a year. The weed management requires intensive operation that reduces net income to the cultivators, in general. Objective of the present study was to apply new innovative practices of eco zero weeding agriculture devised based on management of nitrogen cycle to enhance productivity of garlic and onion. The preliminary field experimental study gave promising results on working of nitrogen cycle management based zero weeding eco agriculture on reducing cost of weeding and enhancement of yield. The increase in yield of garlic was more than three fold in the eco-zero weeding agriculture created at 25% of normal seed rate of lentil sown as sole crop. The field experiment sowed promising prospects of enhancing yields of garlic by application of nitrogen cycle management. Some supplementary management practices showed still better results. Accordingly, a package of practice of eco-zero weeding was formed and recommended for universal adoption as it is endowed with nitrogen and sulphur cycle and encompass quantum mechanics (fixed modes of different operations). Thus, yields of garlic and onion can be raised to new level and several benefits derived.

Keywords: *Eco zero weeding; Biological nitrogen fixation; Intra row cropping; Productivity enhancement of garlic and onion*

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Introduction

Onion and garlic are horticultural crops which are used as vegetables as well as spices, also as salad and medicinal purposes. Their productivity enhancement is largely staked on nutrient application and high yield producing varieties. The plant population viz row to row and plant to plant spacing in the rows are almost fixed. Thus, the productivity increase seems to have reached to its plateau and no innovative technological measures are coming to visualization. Among the crop management researches for other crops such as cereals, oilseeds pulses and vegetable, intercropping has been carried out as cropping management practice, which has proven promising for vertical growth of yields. Because of close growing row to row and plant to plant spacing the garlic and onion such inter cropping are not feasible so not attempted. In the same high density crops, weed emergence, growth and invasion in the space that remain

free of plants. The weeds extract nutrient, water, sunlight and compete with the crops of garlic and onion and insect pest move from plant to plant along crop canopy. Consequently, in order to get rid of such problems the weeding is carried out manually in slow pace, which involve high cost of cultivation leading to reduction of net profit. For onion grown in the rainy season the continuous rains at times do not permit timely weeding as a result of non-workable condition in the field. This situation turns in to over growth of weeds and even total failure of crop. Thus, the strategy of crop management practices for such densely cultivated crops needs to be different.

In this situation if the space occupied by weeds is captured by suitable leguminous crops which fix atmospheric nitrogen, and suppress weeds. The added biological nitrogen will enhance the crop yields on one hand and eliminate need of weeding on the other that will produce the aforesaid enumerated benefits. The close growing rows do not leave scope for carrying out intercropping between the rows as practice for other enumerated crops. However, new mode of intra cropping (Yadav., *et al*. 2013), where leguminous crop is sown within the crop rows has some possibility of enhancing productivity. Because of high density of plant population per ha, it has not been endeavoured by horticulturists. The fear of competition among the plants has blocked the innovative thinking to be devised, resulting in no known studies on intercropping in onion and garlic.

The afore mentioned situation is obvious, unless a thinking is given towards management of weeds by eco agriculture in the garlic field, where weeds grow within the row spaces and intra row space left after plants. In both the situations fixation of biological nitrogen will boost crop productivity even without losing any plant population of the main crops of garlic and onion. In order to overcome the problem of competitions, the plant population of the suitable and compatible leguminous pulse crop needs to be optimised in sequential order treatments containing experimentation, which can be carried out side by side in different field block of onion and garlic to ascertain the optimum seed rate of the nitrogen fixing crop. Once the optimum rates are arrived at, second stage of experiment should be conducted as confirmatory experimentation. Thus, careful and precise planting and experimentation will enable development of innovative crop management practice for densely cultivated crops of garlic and onion. The objective of the present study was to determine the optimum seed rate of eco crop for control of weeds and assessment of benefits of nitrogen fixation on yield of garlic.

Materials and Methods

The prominent onion and garlic cultivating states and regions: Onion–In India onion is grown under three crop season i.e. kharif, late kharif and rabi and in Bihar the farmers follow the same practice. The production 50-60% can be in Rabi & 20-25% in kharif. Maharashtra, Karnataka, Gujarat, Bihar, Madhya Pradesh, Rajasthan, Andhra Pradesh and Tamil Nadu are main onion growing states in India. Productivity in late kharif & rabi is 25 t/ha & in kharif is 8-10 t/ha. The area and production of onion has increased many fold since 1970, but productivity enhancement is slow.

Garlic–Madhya Pradesh, Gujarat, Rajasthan, UP, Assam, Punjab, Maharashtra and West Bengal are the main garlic growing states. Gujarat and Madhya Pradesh produce 44% of country's garlic. Garlic in plains is grown from October to March. Garlic has shown many fold increase in area and production in the country since 1970, s however, like onion the productivity of garlic too has not increased at the same pace, rather it is stagnating at about 5 tonnes/ha from a decade. This must be situation in world over production of garlic and onion. That means innovative technology is standing demand for world over agriculture for raising productivity of garlic and onion. The onion is cultivated in three crops and cultivation of onion during rainy season is largely not carried out due to problem of weed management due to devastating growth, aberrant weather condition not permitting operation of weeding, making cost of cultivation and market price high.

Suitability of Soil and climate: Use, demand and adoption of soil and climatic condition are broad, hence these two crops are grown everywhere, for small house hold use as well as for large scale cultivation of commercial scale. Under all the situations it warrants innovative technology that will make vertical growth and save remaining part of land for other crops, hence it will be an approach to reduce pressure on limited and fixed resource, the Earth.

Role of nitrogen management: Deficiency of nitrogen in onion and garlic can lead to small plants and bulbs, and early maturity. Conversely excess N produces soft bulb, increased susceptibility to field and storage sets and delayed maturity. N is translocate towards the stronger sink near the growing points. Leaf tips die back until whole leaves are lost.

Plants grow slowly, often becoming stunted. Deficiency of N in onion & garlic crops can be corrected by supplementing the nitrogen fertilizers viz Urea, Ammonium Sulphate, Calcium, Ammonium Nitrate etc.

Sulphur Nutrient effects: Onion & garlic are sensitive to Sulphur deficient plants tend to produce fewer leaves, but bulb development is usually uniform yellowing and may, in extreme cases, become thick and deformed. The use of Sulphur containing fertilizers such as Ammonium Sulphate, SSP, Potassium Sulphate and Gypsum as well as Sulphur application in soil @ 20-50 kg/ha or foliar sprays of wetiable S @ 0.2% to 1% can be utilize for correcting S deficiency in onion and garlic. In general, there is less emphasis on fortification of organic sulphur. The bad effects of wet reaction of sulphur cycle does not occur by the fact that onion and garlic are cultivated during winter and well drained condition. While bad effects of bad cycle of sulphur is not hindering, it is also not providing benefit of beneficial effect of sulphur cycle, making sulphate which will help development quality and quantity of onion and garlic. These aspects will be taken up in discussion part of the present study wile formulating management practice for these two crops.

Field Experimental study: Experiments were conducted at experimental farm of Tirhut College of Agriculture, Dholi, North Bihar, India during Rainy season (*kharif*) and winter season (*rabi*) 2016-17. The farm is located on the southern bank of river Burhi Gandak command area of north Bihar at $25^0$98"N latitude, $85^0$60"E longitude and at an altitude of 52.18m above mean sea level.

The soil of experimental site was calcareous alluvial in nature and slightly alkaline in reaction. The soil texture in general is predominantly loamy and sandy loam with pH ranging from 8.2 to 9.4. The average annual rainfall is about 1270 mm out of which nearly 1026 mm was received during monsoon extending from the middle of June to middle of October. The period between 3rd weeks of December to 1st half of January enjoys occasional winter showers. The hot weather commences from April and remains up to middle of June. The summer temperature occurs from May-June between 37°C to 40°C and the minimum temperature for the same period between 17°C to 21.8°C. During rainy season average maximum temperature remains about 33.9°C, average minimum was about 25.3°C. January is coldest month and average maximum was 23.1°C & minimum of 7.7°C. The onion variety agri found Dark red was planted during kharif and winter crop.

The manures & fertilizers were applied as per local recommendation 25q/ha FYM, 120 kg N/ha, 80 kg P_2O_5/ha, 100 kg K_2O /ha and 40 kg S/ha in both the crops. Onion seedlings were transplanted at 6 weeks age, however, garlic cloves were planted at 15 cm x 10 cm. FYM was uniformly spread in the field before ploughing of the plot ½ nitrogen, full phosphor, potash and sulphur was applied before planting of onion seedlings & sowing of garlic cloves. Rest nitrogen was applied in two equal doses after one month & 2 months after transplanting of onion & sowing of garlic cloves. Inter crop (black gram and lentil) as per plan was sown after planting onion & before sowing of garlic. Irrigation & other plant protection operation were done as per need of the crops. The nature of peculiarity of crops, management of fertilisers etc. will be taken up in discussion part of results.

Treatments: The treatments are decided to fit in the narrow range of variation of nitrogen fixing crop to be sown as broad casting before transplanting. The crop may be different viz lentil, alfalfa or peas for garlic and onion, which are cultivated in winter season and black gram or green gram for onion in rainy season. While the green gram and black gram are suitable crop for fixing nitrogen in onion during rainy season, lentil is suitable crop for that purpose in both crops during winter season. In this context a non-legume, no nitrogen fixing crop, but effective in phosphorus solubilisation is fenugreek (methi) will offer insight for management of phosphorus. This study was conducted on garlic with lentil during winter season 2016-17.

Eco zero weeding agriculture Treatments

T1 No weeding and no eco crop i.e. 0 % of normal seed rate,
T2 25% of normal seed rate,
T3 50 % of normal seed rate,
T4 75% of normal seed rate
T5 100% of normal seed rate,
T6 125% of normal seed rate
T7 No eco crop seeding but manual weeding

The treatments are designed to find crop loss due to no weeding on one hand and increase in crop yield due to nitrogen fixation by nitrogen fixing crop on the other. Thus, crop loss due to Weeds = Yield of crop loss due to no weeding = T6–T1 and increase in crop yield due to different levels of nitrogen fixation = {(T2), (T3), (T4), (T5)}-(T1), each one evaluated individually.

Experimental plot design

No of plots = 21; Degree of freedom 7-1 = 6; Degree of freedom of replication = 3-1 = 2; Error degree of freedom 6 x 2 = 12 (Sufficient for statistical significance). In our present study T6 dose was not tried and T7 became T6 in this study.

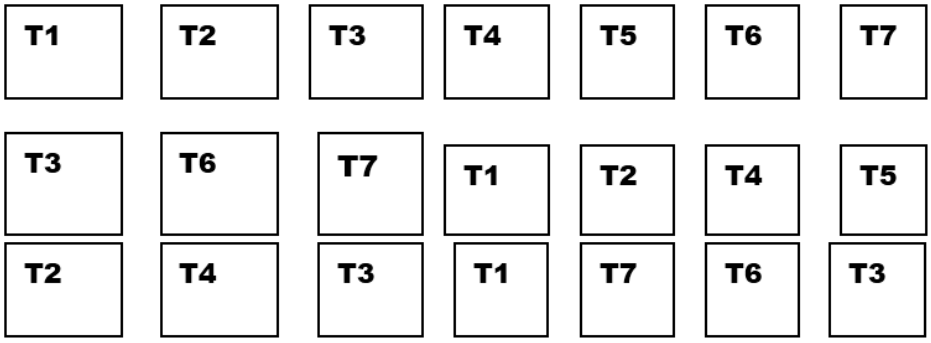


Figure 1: *Lay out of field experimental block for eco agriculture.*

(Plot size 100 cm x 100 cm gross plot size).

Observation to be recorded: Progressive growth, yield, biomass, harvest index, wight of bulb, test weight of garlic kernals, weed types, weight, maturity date, flowering of lentil, weight of lentil grain, keeping quality test and residual nutrient status of soil at harvest etc.

This was first attempt to evaluate effect of eco-zero weeding agriculture at the Research Farm of Tirhut College of Agriculture, *Muzzaffar pur,* Bihar. The soil is light textured and annual rainfall about 1400 mm. The treatment details are given. The crops viz onion in rainy season was planted and black gram (urd) was sown as eco building crop. The experiment could not be maintained due to shortage of well-equipped assistant and vandalism by the local grass cutting individuals.

In the winter season, the crop was replaced by garlic and pulse crop by lentil, another leguminous crop. The eco treatment, plant spacing and plant population remained the same as for onion. The field crops are depicted in Figure 2. The yield data per plot are converted in q/ha Table 1.

Statistical analyses: The experimental treatments are designed to generate various information with statistical sufficiency. Further, the treatments from T1 to T5 can be analysed for finding dose of the eco seeding for finding various objective in cultivation of garlic and onion.

Results

The onion and garlic are dense close growing transplanted crops; the plant population/ha is very high. The usual row to row spacing is 15 cm and plant to plant 10 cm. Weed control is carried out manually, that involves huge cost of cultivation, a reducer of net benefit. Since this is the first study on this topic addressing new aspect of eco-zero weeding agriculture [Figure 2], main focus is to address the major benefit of this innovative technology on enhancement of yield of garlic. Therefore, effort have been concentrated to substantiate the relevance, effectiveness, efficiency, impact and sustainability of the technology with theory and experimentally generated data on ideal crop of onion and garlic, which are used for different purposes and in forms. The crop transplanted/sown in high density plantation and no tillering of the crop. The yield levels have stabilised and no enhancement in yield is coming up due to innovative technological innovations. Once this is established by experimental data, other benefit of innovative technology will find fast acceptance by the scientific community. The entire concept is based on innovative application of nitrogen cycle management. Among various benefits, the most challenging is the management of weeds, which consume nutrients, cause solar light, nutrient, moisture and space completion and cause drastic reduction in yield of crop. The eco zero weeding agriculture produce benefits in several aspects which will be taken up in the later of the present study.

Yield variation in relation to weeding: The data on yield per plot was recorded and presented in Table 1. The yield of garlic in no weeding and no nitrogen fixing eco crop was 55.5 q/ha and of T7- fully weeded plot 35.5q/ha. Thus, no weeding treatment produced 20 q/ha more yield than that with fully weeded plot. On the other hand weeding involved investment of high cost. This situation indicates a fact which otherwise is contrary to common belief that weeding will overcome crop loss, in general. Since garlic is shallow rooted crop, weeding involves tilling of surface layer that causes drying of shallow root zone of garlic, hence producing stress for the crop. In the no weeding case there is nitrogen fixation even with weeds that support crop on one hand and no disturbance to cause moisture loss from shallow root zone. This mechanism is more effective in experimental site with light loamy and sandy loam soil at *Dholi. Samastipur, Bihar*.

Enhancement in yield by nitrogen fixation: Regarding effect of fixation of nitrogen on yield of garlic there are two situations. The gain in yield of garlic over that of fully weeding manually versus no eco zero weeding agriculture are at 25% T2-T6 (114-36), 50% T3-T7 (111-36), 75% T4-T7 (79-36) and 100%, T5-T6 (71-36) levels are 78, 75,43,35 q/ha, respectively. Under the other situation i.e. in contrast to no weeding and no eco crop, it is at 25% T2-T1 (114-55), 50% T3-T1 (111-55), 75% T4-T1 (79-55) and 100 % T5-T1 (71-55) are 59, 56, 24 and 16 q/ha, respectively. The insight of the variation against complete weeding and against no weeding are depicted in Figure 3. The gain in yield due to nitrogen fixation is higher when comparison is derived from full weeding is higher at all levels of Eco establishment, than that under no weeding, as a result of nitrogen fixations by leguminous weeds. The Figure 3 shows a sharp decline in yield after 50% level to 75% level then decrease is again slow. This trend indicates a polynomial variation, which will be analysed in the following part of the study.

Figure 2: *Experimental view at the research Farm of Tirhut College of agriculture, 2016-17.*

Treatment No.	Treatments	TDW (Kg)	LER	LER for green gram and pearl millet	TBY/plot (q/ha)
T1	Garlic; no Lentil	1.330	1.0	1.0	55.5
T2	Garlic + 25% Lentil (1g)	2.740	2.06	1.34	114.0
T3	Garlic + 50 % Lentil (2g)	2.670/3.0087*	2.01/2.321*	1.51	111.4/125.5*
T4	Garlic + 75 % Lentil (3g)	1.882/2.004	1.415/2.044	1.39	78.5/98.9
T5	Garlic 100 % Lentil (4g)	1.702/1.923	1.28	1.23	71.0/80.2
T6	Garlic with full package, No Lentil	0.850			35.5

Note: TDW-Total dry weight, TBY-Total bulb yield;

*Data based on trend analysis of earlier intra row cropping (Yadav., *et al*. 2013).

Table 1: *Yield data from a pilot trial on zero weeding eco agriculture.*

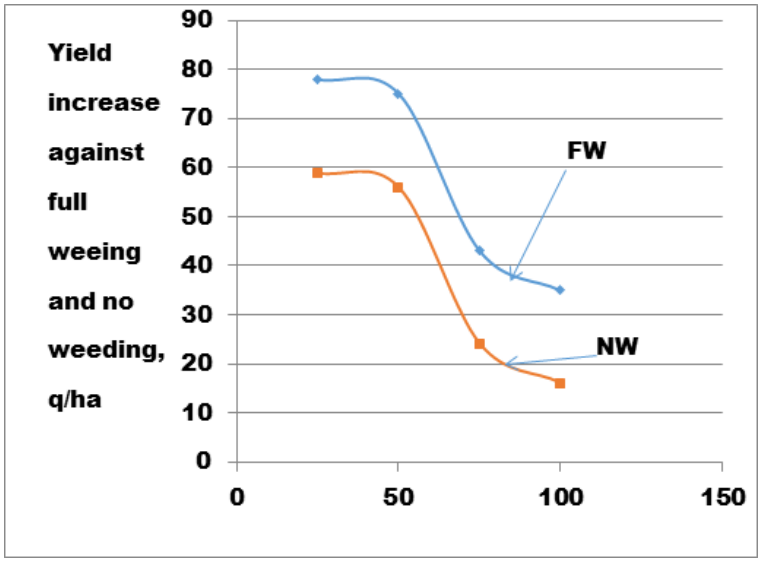


Figure 3: *Increase in garlic yield against full weeding and no weeding in relation to eco-established levels.*

Optimum dose of nitrogen fixing eco crop and maximum yield: The trend of enhancement in yield due to nitrogen fixation revealed that it follows a polynomial trend. Hence, yield data recorded under the experiment for treatment T1 no nitrogen fixation T5, 100 % seed rate of nitrogen fixing crop lentil were analysed and resulting graph is shown in Figure 4. The coefficient of determination indicates that 71% of yield depends on biological nitrogen fixation. Utilising the polynomial regression equation level of nitrogen fixing crop optimum seed rate was computed and presented Table 2. The optimum seed rate was 51%. With this optimum seed rate the maximum yield of garlic was 111q/ha. The experiment result had revealed highest yield of 114 q/ha, but it got moderated and the corresponding maximum yield was 111q/h. This situation indicates that inter-competition must have suppressed crop of garlic, hence the

maximum yield got reduced from 114q/ha to 111q/ha. There can be some reason related to precision and care required in the study. In order to study trend how yield can respond when some potential improvement care is infused in data at level 50, 75% and 100%, based on trend observed in another study (Yadav, et al 2013) and incorporated changes indicated in Table 3. Using the data another polynomial relation was derived [Figure 5]. The coefficient of determination increased to almost 90%., thereby revealing possibility of enhancing yield by better crop management with respect to fixation of nitrogen. The weeding is not being carried out as it is zero weeding agriculture, inoculation of nitrogen fixing bacterial compound would be prospecting approach. The optimum dose of eco crop assessed was 55%, and the maximum yield of garlic corresponding to this optimum dose of eco crop through the polynomial relation was 125 q/ha. This increase fortifies that experiment needed some better care and bad effect of inter-competition can be shifted further to harvest higher yield. Still better crop management does indicate possibility of better prospects, which will be taken up in the subsequent part of the study

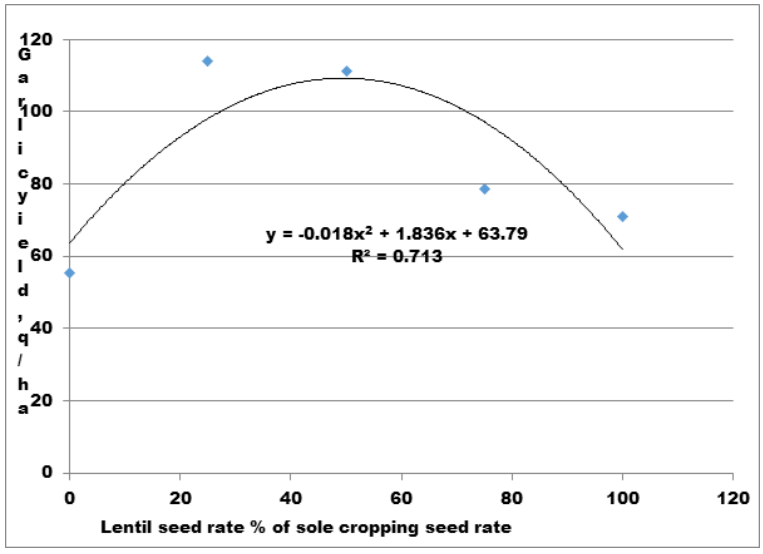


Figure 4: *Polynomial trend of yield with actual experimental data.*

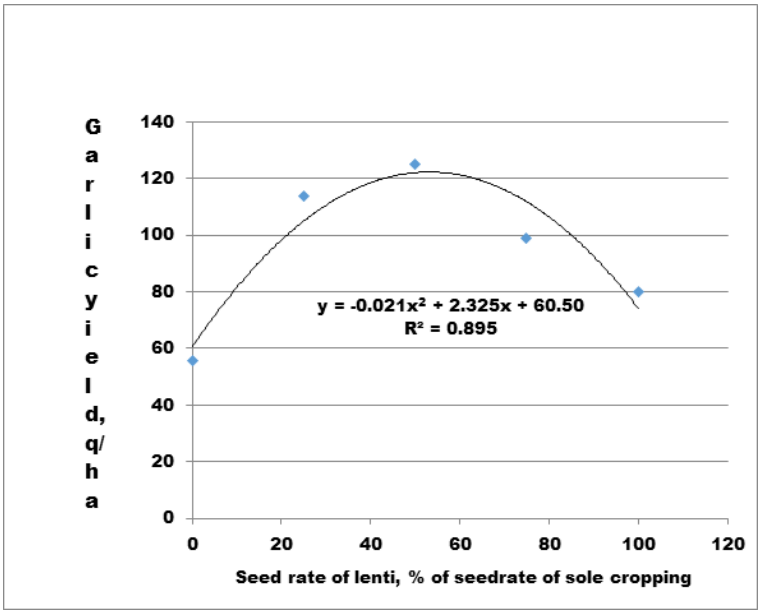


Figure 5: *Polynomial equation for yield after adjustment for potential increase.*

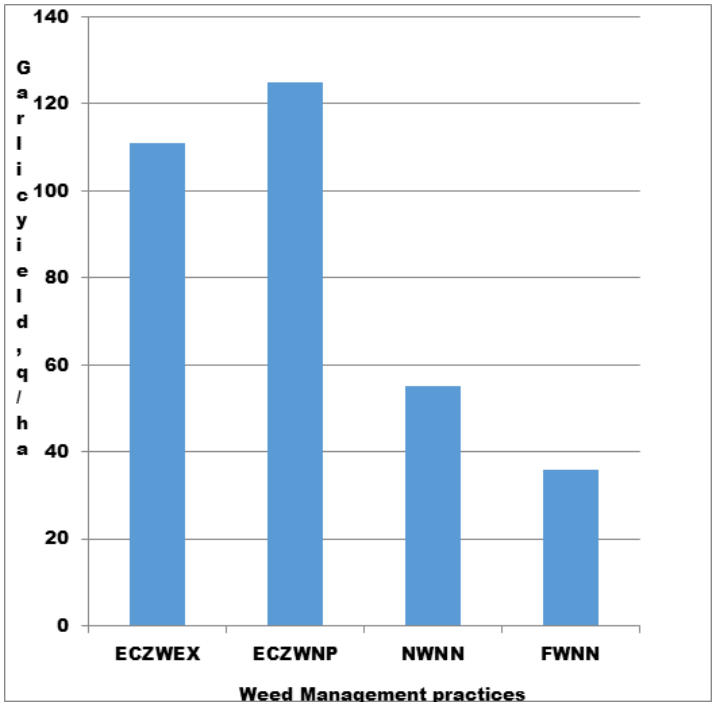
S. No	Use of data set	Polynomial relation	R^2	Maximum yield at seed rate, %	Maximum yield, q//ha
1	Actual recorded	$Y = -.018X^2 + 1.836x + 63.79$	.713	51	111
2	With slight adjustment at 50% seed rate and beyond	$Y = -0.021X^2 + 2.325x + 60.50$	.895	55	125
3	No weeding no nitrogen management	-	-	-	55
4	Fully weeded, but no nitrogen cycle management	-	-	-	36

Table 2: *Determination of optimum rate of lentil seed for eco-zero weeding agriculture for garlic.*

The different methods of weed management and their effect on yield are shown in Figure 5. The existing practice of weeding, by manual weeding in garlic, involve high cost, thereby will reduce B/C ratio for the cultivators. Treating this as a control, the LER will be 1. As against this zero weeding agriculture with eco-agriculture practice developed in the present study show great prospects for enhancing yield of garlic, a close growing crop, for which no innovative practice could be devised. As indicated, there occurred some inadequacy of experimental care, nevertheless the data revealed prospects of eco-zero weeding for garlic. This fact reveals that the technology of eco-zero weeding agriculture is robust and effective in wide range with tolerance. It is found that lentil sown at 51% of normal seed rate of sole crop of lentil produced maximum yield 110q/ha. With slight improvement in yield of this study at per trend established in other parallel experiment the yield of garlic reaches to 125q/ha, which is an exemplary yield of garlic. Further, there is scope of enhancing nitrogen fixation by inoculating phosphorus solubilising bacterial compound. Application of ultimate green irrigation to keep the surface layer at 75% of saturated moisture by sprinkler irrigation will prove boon for shallow rooted garlic crop. Thus, this study has opened new door for prospecting cultivation of garlic.

Weed management practices and their effects on yield of garlic: A summary of weed management practices and resulting yield are presented in Figure 6. Eco –zero weeding agriculture has shown enormous yield increase. Some improvement in practice will further enhance the yield, which otherwise were not imagined. No weeding even increased yield. Similar effects were found by another study (Banik., *et al*. 2006). In the study it was found that weeds reduced yield up to 28%, against yield of fully weeded crop of wheat. The residual nutrient in soil was about 24% more than in control without weeds. When weeds include alfalfa the loss in yield due to weed was reduced to 16%. In the densely planted garlic crop the presence of weeds increased yield instead of depletion, because of drying of surface soil in weeding induced disturbance of soil layer. It also fortified that weeding is proving ineffective and costly. Thus, these results confirm and display good approach taken up in conceptualization and experimentation that yielded promising result leading to innovative eco zero weeding agriculture technology. This study has created new avenue for rain fed agriculture in particular and irrigated agriculture, in general. This innovative technology surpasses all innovations being developed to meet challenge of weed management in world agriculture, viz weeding by robot, smart agriculture and specialized weeding machines. The adverse weather condition make these innovative technology an applicable and ineffective, so problem of weed management remain unsolved. In this situation eco –zero weeding agriculture proves to be the best technology, as it is non-monetary input practice, remain working under all adverse condition of weather creating non conducive for field operations.

Enhancement in LER and Net return to the cultivators: The eco-zero weeding agriculture technology of production of garlic versus yield under full weeding, no weeding and recommended optimum dose of eco zero weeding crop seed rate producing yields are collated in Table 3 to form basis of making package of practice for cultivation of garlic.



ECZWEX- eco-zero weeding nitrogen cycle management under this experiment; ECZWNP-eco-zero weeding nitrogen cycle management potential effects; NWNN-No weeding no nitrogen and FWNN-fully weeded manually, but no nitrogen cycle management.

Figure 6: *Yield of garlic under Eco-zero weeding agriculture versus no weeding no nitrogen management and full manually weeded, but no nitrogen cycle management.*

S. No	Weed management practices	Yield, q/ha	LER	Cost involved, Rs/ha	Lentil quantity of seed, kg/ha	Additional cost, Rs/ha#	Gross income, Rs	Net benefit, Rs/ha
1	Fully weeded manually	35.5	1.0	3000	0	3000	106500	103500
2	No weeding	55.5	1.563	0	0	0	166500	166500
3	Zero weeding agriculture observed from the experiment	114	3.221	0	51 (12.75)	634	342000	341366
4	Zero weeding with increased potential*	125	.3.521	0	55% (13.75)	688	375000	374312

Table 3: *Zero weeding eco-agriculture practice and other existing weed management practices for cultivation of garlic.*

Still better prospects for enhancing nitrogen fixation, phosphorus solubilisation.

+Cost of lentil seed rate Rs 50/kg, Seed rate of lentil as sole crop 25 kg/ha (Chaudhary, 2012).

#Sale price of garlic Rs 30/kg. Note Currency US $ 1 = INR 65 (approximate)

With the fore mentioned example cases it is sufficiently substantiated that pulse based eco zero weeding agriculture produces multiple benefits of increase in LER, increased benefit cost ratio (B/C) [Table 3], weed control, reduction of erosion and land degradation, increase in drought endurance, potential for insect and pest control etc. The yield increase with sustainability and quantity enhancement

are substantiated. Thus, new toil free eco-agriculture shows the present and future yield potential with the technology presented in the study. The potential yields will get easily achieved by combining again a supplementing technology of racy nature agriculture (Yadav, 2013, Yadav and Chaudhary, 2014). If suitable moisture building mechanism is created, still higher high yields than achieved can be harvested. Yadav (2015) developed ultimate green irrigation practice for this purpose, which will be highly suitable for shallow rooted crops such as garlic and onion.

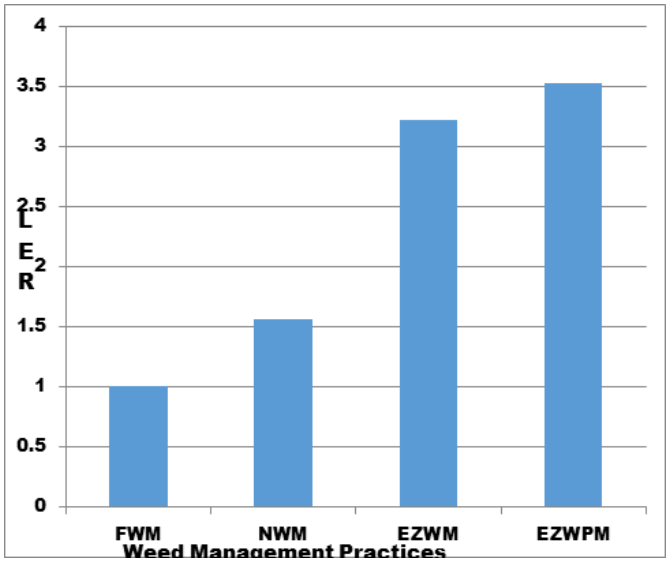


Figure 7: *LER as affected by weed management practices.*

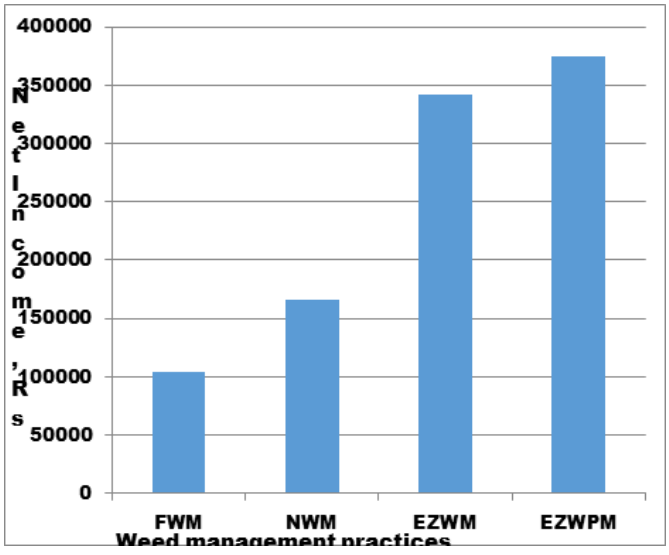


Figure 8: *Net income from cultivation as affected by weed.*

Management practices

The fore going results on manifolds enhancement of yield of garlic by the innovative technology culminating in eco zero weeding agriculture have been substantiated to be effective. These results are further discussed for their relevance, effects, efficiency, impact and sustainability.

Discussion

The innovative technology of eco-zero weeding agriculture is highly suitable for cultivation of garlic crop, particularly with regard to weed management. Weeding in high density planted crop is time consuming that demands cost. Further, the general belief that weeds interfere and reduce yield of crop is revealed to be not true, as garlic yield was more under no weeded treatment. Thus, no benefit of weeding has been found to accrue in the soil condition where top soil layer gets quickly dried and crop suffers moisture stress, resulting in reduction in yield on one hand and expenditure on account of cost of weeding. The yield of garlic with no weeding was more, that fortifies fact of some nitrogen fixation by weeds supported increase in yield of garlic against fully weeded crop of garlic.

The trend of variation in gain in yield of garlic under fully weeded and no weed plot at various level of eco establishment make it clear that crops sustain competition up to about 50 eco establishment. Drastic reduction occurs due to competition that reveals a polynomial trend of variation.

The polynomial analysis and trend of variation in yield of garlic showed 71% dependence on nitrogen fixation. The optimum dose of eco level was 51 percent and with this dose the optimised yield of garlic was 111q/ha. The influence of technology on enhancing garlic yield is robust, hence it overcome the inadequacy of experimental precision to some extent. In order to see response that if some better crop management practices are given to the garlic crop some innovative potential management support was given [Table 3], that revealed the dependence of crop on nitrogen fixation up to 90%. This condition enhances tolerance of competition and increase in yield up to 125 q/ha, which are very well and strongly revealed the efficacy of the technology. In the context of improvement in component practices to make it still better than the level demonstrated so far, the step by step component review is to be resorted to. The crop density is maintained thus, entire space is contributing some yield to form global yield /ha. Since it is zero weeding hence that part is also fortified with evidentiary facts. It is only nutrient and irrigation part that needs some specific review.

In the ongoing practice garlic field is applied 25 q/ha FYM, 120 kg N/ha, 80 kg P_2O_5/ha, 100 kg K_2O /ha and 40 kg S/ha. Taking account of NPK and sulphur status of the crop some insight of prospect of management can be clear. The nutrient summary presented in Table 4 reveals that it is sufficient and microbiological inoculation for nitrogen fixing and phosphorus solubilisation will be effective. This effect is brought by eco-crop and its inoculation and addition of peas will help phosphorus solubilisation. This aspect can be created that will further increase efficiency of eco-zero weeding agriculture. Nevertheless, the present field experimental study has accomplished its desired objective of validation and substantiation of the new innovative technology of eco-zero weeding agriculture.

S. No	Nutrients	Organic from FYM + 25q/ha	Inorganic	Total, kg/ha*
1	N	13.5	120	135.5
2	P	7.75	80	87.75
3	K	12.75	100	112.75
4	S	12.5	40	52.5
5	Fe	8.25	-	8.25
6	Mn	2.93		2.93
7	Cu	.188		.188
8	Zn	1.461		1.463

Table 4: *Status of nutrient and possible improvement for further increase of yield of garlic.*

*Remark Nutrients seem to be sufficient, inoculation of pulse crop lentil of eco-zero weeding crop with *Sinorhizobium meliloti and Bacillus megaterium*) should be adopted that will further enhance yield of garlic.
+contents based on Biswas., *et al*. 2012.

The nutrient status is sufficient. Study on fenugreek (Adak and Sachan, 2013) showed that such doses of nutrients are efficiently utilised when microbial nitrogen fixation occurs, solubilisation of phosphorus induces high uptake by grain and straw. Yadav (2012, 2013) reported that application of aerobically decomposed compost, which adds organic sulphate will enhance yield of sulphur loving crops such as garlic and onion. Thus, in garlic this effect will get to produce still higher yield. This aspect has been shown vide Figure 4 and Figure 5. Thus, it is becoming clear that addition of PSB will be effective as the eco fortifies the organic N. Inoculation of rhizobium culture will be very effective that will enhance efficiency in increasing crop yield. So far researches have been conducted on effect of inoculations on yield of fenugreek (Adak and Sachan, 2013), microbial formulations (Sharma., *et al*. 2013) on yield of tomato and biological health of soil of different cropping systems (Manna., *et al*. 2013), This innovative study developed an exemplary yield producing technology of weed management in agriculture world over, in geheral. In this situation the knowledge of the microbiological aspects, can be made use of to enhance efficiency of the eco-zero weeding agriculture in time to come.

The study has demonstrated increase in LER and Net Return [Figure 7, Figure 8] to the cultivators. These aspects will make the eco-zero weeding agriculture highly attractive for the cultivators. This technology also eliminates risks of crop failure due to bad weather condition, particularly rainfed agriculture. The innovative technology also helps make right public governance. These and many beneficial aspects will get quantified by further researches, as the first part of the technology of eco zero weeding agriculture has been proven, beyond any doubt.

The eco–zero weeding agriculture, which is a manifestation of practice from management of nitrogen cycle (Yadav, 2012, 2013, 2014, 2015a,) is very relevant innovative technological solution of problem of weed management in world agriculture. It is the most effective in weed management as its working continues under even unfavourable weather condition induced not workable condition in the field. The present study has established efficiency and effectiveness. In addition to the benefit of yield, increase in LER and net benefit, this eco- zero weeding agriculture works as panacea shrine for total solutions in agriculture. As the success of good crop is assured under all-weather situations, the technology is highly sustainable. Thus, eco-zero weeding agriculture technology fully meets all aspects of the relevance, effects, efficiency, impact and sustainability (REEIS).

Strength, weakness, opportunity and threat (SWOT) analyses was also carried out as it becomes desirable aspect for any new innovation. The eco-zero weeding agriculture is based on the theory of nitrogen cycle and is also backed for it robust working under field condition, hence it is has very high strength. It overcomes and surpasses all worldly innovations for weed management in agriculture. As the other innovations have some limitations and among them the most prominent one is no functioning under the unfavourable condition due to aberrations in weather. The climate change is adding to the severity of this limitation. The eco-zero weeding technology is having no limitation of any kind, hence, there exists no threat to this innovative technology in meeting all challenges of weed management in agriculture. Regarding opportunity, it is emphasised that it is practically non-monetary input involving technology (as revealed by the expenditure (data in Table 4). It is a panacea shrine for total solutions viz for economics, runoff and soil loss reduction, elimination of land degradation due to nutrient deficiency, making shortfall in pulse production and reduction of emission (Yadav, 2014, 2015a) of nitrous oxide (N_2O), a Green House Gas, largely responsible for depletion of ozone layer (Wubble, 2009), that shows huge opportunity created by this technology.

Conclusion

This study devised innovative technology of eco-zero weeding agriculture, nitrogen fixation prudent, and application for enhancing yield of garlic (equally applicable for onion) to many fold. Yield responses of different weed management practices are presented, which revealed exemplary increase in yield of garlic with eco zero weeding agriculture with plenty scope for future improvements. Further, vertical growth will be built for these to crops by management practices when raised bed and furrow planting is carried out and ultimate green irrigation practice is adopted. Slight improvement in size of garlic and onions, which are largely non-tillering crops will be real indicator of performance of eco zero weeding. When due care is maintained the lentil grain yield will be produced that will enhance LER of the cropping. Since both garlic and onion are sulphur loving crops application of NADEP compost 20 days before planting and mixing in soil will further increase yield and improve quality of the produce.

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