Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(1): 1881-1886
Received: 22-11-2018
Accepted: 26-12-2018

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Cumulative effect of tillage and weed management practices on soil property, weed dynamics and productivity of mungbean (*Vigna radiata* L.) in rice-wheat-mungbean cropping system

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Abstract
A field experiment was conducted during 2014-15 and 2015-16 at DWR, Jabalpur (M.P.) to see the Cumulative effect of tillage and weed management practices on soil property, weed dynamics and productivity of mungbean (*Vigna radiata* L.) in rice-wheat-mungbean cropping system. Fifteen treatments, comprising of five tillage practices as main-plot and three weed management practices as sub-plot treatments were laid out in split plot design with three replications. Zero tillage in mungbean after zero tillage in rice and wheat with or without previous crop residues has lower soil pH, higher EC, OC, N, P, K content and weed density. Whereas, zero tillage in mungbean after conventional tillage in mungbean with previous crop residues reduces the bulk density and enhances the crop growth and gave higher seed yield with better weed control than other treatments. Similarly, regular or rotational use of herbicides equally control weeds in mungbean and gave higher seed and stover yield of mungbean.

Keywords: Mungbean, zero tillage, crop residues, weed management, root nodules, rice-wheat-mungbean

Introduction
Rice-wheat-fallow is the dominant cropping system of the central India. Generally, fields remain fallow for 70–80 days during summer after the harvest of winter crops. But, short-duration summer legume crop like green gram can be grown during this period with assured irrigation. Now a days this practice has received wide acceptance among the farmers and has occupied an area of about 1.0 Mha as it provides additional income, improves soil fertility and ensures efficient land utilization (Sharma *et al*., 2000; Sharma & Sharma, 2004) [14, 13]. Current cultivation practice involves conventional tillage (excessive tillage) for good seed bad preparation and facilitates proper germination but cause soil health deterioration including loss in soil organic carbon. Now conservation agriculture become popular over the past 2-3 decade now for achieving sustainability in intensive cropping system (Sharma *et al*., 2012) [12]. It involves zero tillage, retention of previous crop residues and inclusion of legumes in summer. As tillage is the very important practice which cause direct or indirect (cumulative) effect on weed dynamics and succeeding crop growth. Zero or minimum disturbance of soil under CA cause higher weed seed bank (Kumar *et al*., 2005) [7]. Whereas, lower density of *Phalaris minor* was reported in wheat due to the lower weed seed bank in zero tillage practices (Mishra and Singh, 2011) [10]. Continuous zero tillage in maize-wheat-mungbean cropping system gave higher root dry weight and volume but lower root length and seed yield of succeeding mungbean due to higher bulk density in zero tilled plots (Meena *et al*., 2015) [9]. Beside this zero tillage system shows higher weed seed bank as compared to conventional tillage system, thus weed management is very important part of conservation agriculture (Sharma *et al*., 2015) [17]. Weeds can be controlled by herbicides, but it can be affect soil bio-chemical properties. Kiran *et al*. (2015) [6] observed that root length, shoot length, seedling vigour and seed yield of succeeding mungbean were not affected when bispyribac was applied in the previous transplanted rice. However, least research have been reported on cumulative effect of some herbicides on succeeding crop Since many previous researcher have reported direct effect of tillage and weed management practices on weeds and crop growth but information on cumulative effect of tillage and weed management practices done in rice and wheat are still lacking. Henceforth, comprehensive study was planned to see the cumulative effect of tillage and weed management practices on soil property, weed dynamics, growth and yield of mungbean in rice-wheat-mungbean cropping system.

Materials and Methods

Experimental site and location

The field experiment was conducted at Research Farm, ICAR-Directorate of Weed Research, Maharajpur, Jabalpur (M.P.). The present investigation is a part of long term experiment on weed dynamics, crop productivity, soil properties and economics of rice-wheat-mungbean system as affected by tillage and weed control under conservation agriculture, which has been started since *kharif* season, 2012-13. Thus, it was the third crop cycles of the experiment. Adequate research facilities *viz*., irrigation water, seeds, fertilizers, equipments and labours etc. were available on the research farm as per needs to conduct the farm works smoothly.

The climate of Jabalpur region is typically subhumid, featured by hot dry summer and cool dry winter. Jabalpur is situated at 230 09' North latitude and 790 58' East longitude with an altitude of 411.78 metres above the mean sea level. It is classified under “Kymore Plateau and Satpura Hills” agro-climatic zone as per norms of National Agricultural Research Project (NARP), New Delhi. The mean annual rainfall of Jabalpur is 1350 mm, mostly received between mid-June to end of September with a little and occasional rains in remaining parts of the year. The mean monthly temperature goes down to the extent of 4 ^{0}C during winter, while the maximum temperature reaches as high as 45 ^{0}C during the summer. Generally, relative humidity remains very low during summer (15 to 30%), moderate during winter (60 to 75%) and attains higher values (80 to 95%) during rainy season. The soils adjoining to Jabalpur are classified as “vertisol” as per US classification of soil. The soils of the region are medium to deep in depth, and black in colour, clay-loam texture and neutral in soil reaction. These soil swell by wetting and shrink by drying.

Treatment details

The experiment was consisted of fifteen treatments comprising of five tillage practices as main plot treatments *viz*., T_1-conventional tillage in rice + *Sesbania*-conventional tillage in wheat-zero tillage in mungbean, (CT+S+(R)-CT(W)-ZT(M)], T_2- conventional tillage in rice+ *Sesbania*+ mungbean residues-conventional tillage in wheat- + rice residues-zero tillage in mungbean+ wheat residues (CT+S+MR(R)-CT+RR(W)-ZT+WR(M)], T_3-,Zero tillage in rice + *Sesbania* – zero tillage in wheat-zero tillage in mungbean, (ZT+S(R)-ZT(W)-ZT(M)],T_4- zero tillage in rice + *Sesbania* + mungbean residues-zero tillage in wheat+ rice residue-zero tillage in mungbean + wheat residues, (ZT+S+MR(R)-ZT+RR(W)-ZT+WR(M)], T_5- conventional tillage in transplanted rice-conventional tillage in wheat CT(TRP)-CT(W)-fellow and three sub plot treatments *viz*.,W_1- weedy check, W_2- regular application of bispyribac 25 g/ha in rice (PO), application of tank mix solution of clodinafop 60 g/ha and sulfosulfuron 25 g/ha in wheat (PO) and application of pendimethalin 750 g/ha(PE) (during both the years) and W_3- rotational application of chlorimuron +metsulfuron-methyl 4.0 g ready mix /ha during first year and bispyribac 25 g/ha (PO) during second year in rice and application of clodinafop 60 g/ha+2,4-D 0.5 kg/ha during first year and mesosulfuron + iodosulfuron methyl 12+2.4 g/ha (PO) during second year in wheat and application of pendimethalin 750 g/ha(PE) during both the years were laid out in split plot design.

Crop residues

Sun dried residues of rice and wheat (5 t/ha) and mungbean (3 t/ha) were applied to the succeeding crops of wheat, mungbean and rice, respectively. The crop residues were spread as mulch after sowing.

Crop establishment of mungbean

In some part of India mungbean is grown in summer also under asuured irrigated condition. It was sown in last week of march to first week of April in central India. Samrat (PDM 139) is a early maturing mungbean variety. The plant height are 30-50 cm, dwarf, erect, small leaflet, profuse poddling with long brownish pods. Seeds are green medium bold attractive with luster. it is very well fitted in rice-wheat cropping system due to its short duration. It sown with the help happy seeder under zero till condition by using a seed rate of 20 kg/ ha. This practice saves lot of time and reduce cost of cultivation which is very important for summer crop (Komal *et. al.,* 2015). Before the sowing the seeds were treated with thirum 1.5 g/kg of seed to make them free from seed borne diseases and inoculate with rhizobiom @ 25 g/ha for better nodulation. To maintain the optimum plant population gap filling and thining was done after 12 days of sowing. A recommended dose of fertilizers (20 kg N+60 kg P_2O_5+ 20 kg K_2O/ha) was applied to mungbean in all plots. 100 % of recommended dose of fertilizer was applied at the time of sowing. The N, P_2O_5 and K_2O fertilizers were applied through urea, single super phosphate and murate of potash, respectively.

Sampling Techniques

Plant population

The plant population per metre row length was recorded at 20 DAS from five row selected randomly and mean number of plants per metre row length was worked out and later converted into plants per square metre by multiplying with number of row in one metre area. For plant growth and yield attributes five randomly selected plants from each plot were tagged and their height and number of branches, pods/plant and seeds per pod were measured. For counting of effective nodules per plant five plants from each treatment were uprooted at 45 DAS with the help of a fork by removing the entire roots along with soil lump and then was kept as such in bucket, filled with water for half an hour. The roots of each plant were then gently cleaned carefully so that nodules are not separated from roots. After that, all the nodules were removed from the roots and pressed between two fingers for assessing the presence of leg-hemoglobin so as to count the effective nodules. Thereafter, the total number of effective nodules per plant was counted and mean was worked out. Yield attributing characters like number of pods, number of seeds per pod and seed index were taken by 10 randomly selected plants of harvested plots and Finally, mean was computed.

Seed yield

The seed yield per net plot was recorded after winnowing the produce, with the help of double pan balance. Finally, seed yield of each plot was converted into seed yield per hectare by multiplying with appropriate conversion factor.

Stover yield

The stover yield per plot was determined by subtracting seed yield (economical yield) of each plot from biological yield (bundle weight) of the same plot. This was later on converted in to stover yield per hectare by multiplying with the same conversion factor which was used in case of seed yield per hectare.

Change in physico- chemical properties of soil

The soil samples were taken from each plot after completion of both crop cycles during the investigation to assess the effect of different treatments on the changes in various physical and chemical properties of soil over their parental status. These soil samples were taken with the help of screw type soil auger from each pot and tagged with luggage labels. This sample taken from all 3 replications were mixed treatment wise and then dried well. Thereafter, treatment wise composite samples were made and after this, there were powdered with the help of morter and pistal. Then, the samples were subjected to various analysis for physico-chemical properties due to the effect of different treatments over their initial status were determined

Table 1: Details of methods used in determination of soil physical and chemical properties

S.N.	Soil parameter	Methodology
1. Physical properties	Bulk density	Core method (Blacke and Hartge, 1986) [18].
2. Chemical properties	Soil pH	pH metre (Piper, 1967) [19].
	EC (ds/m)	Soluble method (Piper, 1967) [19].
	Organic carbon	Walkey- black method (Walkey and Black, 1934)
	Available nitrogen	Alkaline permagnate method (Subbiah and Asija, 1956) [21].
	Available phosphorus	Olsen's method (Olsen *et al*., 1954) [22].
	Available potassium	Flame photometre method (Hanwey and Heida, 1952) [23].

Results and Discussion

Soil chemical property

Effect of tillage on physico-chemical property of soil

Bulk density of soil

Data presented in table….showed that soil was remained almost unchanged under different tillage and weed management practices after first year of the field experiment. However, during second year, the minimum BD was found when conventional tillage was done in DSR and wheat and zero tillage in mungbean in the presence of preceding crop residues under CT+S+MR(R)-CT+RR(W)-ZT+WR(M) (T_1) in rice-wheat mungbean cropping system. However, the bulk density was more when conventional tillage was done in transplanted rice and wheat under CT(TRP)-CT(W)-fellow system (T_5). In case of conventional tillage under CT+S+MR(R)-CT+RR(W)-ZT+WR(M) soil becomes loose and pulverized by intensive tillage operations. In addition to this previous crops residues were also incorporated during the field preparations in conventional tillage system. As a consequence, porosity was improved, which resulted into minimum BD (Hussain *et al*., 1998) [24]. In case of conventional tillage in transplanted rice under CT(TPR)-CT(W)-fallow system, soil structure was purposely destroyed by puddling to avoid percolation losses of water and smooth cultivation of rice. However, soil become compact after drying due to destruction of macro and micro pores and finally increased soil bulk density (Forbs and Watson. 1996) [25]. Similar results were also reported by Sharma *et al*. (2004) [13] at Pantnagar, Sharma *et al*. (2006) [20] at Sabour (Bihar), and Jha (2010) [26] at Jabalpur.

Soil pH, electrical conductivity and organic carbon

Soil pH, electrical conductivity and organic carbon from their initial status are presented in Table 2.The above parameters statistically did not vary due different tillage and weed management practices in rice-wheat-mungbean cropping system. But, numerically zero tillage in all component crops in presence of previous crop residues (T_4) had lower pH but higher EC and organic carbon contrary to conventional tillage in both transplanted rice and wheat under CT(TPR)-CT(W) (T_5). Plant nutrients and organic matter are accumulated under zero tillage in presence of previous crop residues. After the decomposition of plant residues organic matter, carbonic acids are produced which declined soil pH (Rasmussen, 1999) [27]. EC is inversely proportional to soil pH, so that soil EC was higher in T_4. Das *et al*. (2016) [4] also reported higher soil EC due to increase in organic matter under conservation agriculture. Reduction in tillage intensity resulted into less disruption of soil aggregates and thus increase more organic carbon inside the macro aggregates (Six *et al*., 2000) [28]. Similarly, Das (2016) [4] also reported higher soil organic carbon under direct seeded rice + brown manuring- zero till in wheat. Reason behind higher pH, lower EC and OC Under CT(TPR)-CT(W) that in transplanted rice plants grew under anaerobic condition after puddling, which neutralized the soil pH (Reddy, 1992) [29]. In addition to this, wheat was also cultivated after conventional tillage without amendment of previous crop residues. Consequently, CT(TPR)-CT(W)-fallow system showed higher pH than other treatment in second year, but lower than its initial status.

Available N, P and K in soil

It is evident from the data that available N, P and K in soil did not exhibit remarkable changes over their initial status under different tillage and weed management practices during both the years of experimentation (Table 3). However, during second year, ZT+S+MR(R)-ZT+RR(W)-ZT+WR(M) recorded numerically higher N,P and K compared to other tillage practices. The present investigation was four year old and previous crop residues were regularly added in ZT+S+MR(R)-ZT+RR(W)-ZT+WR(M) system which might have enriched soil with NPK as a resulted of decomposition of soil organic matter. Alam *et al*. (2014) [30] also reported higher N in zero tillage as compared to conventional tillage in wheat-mungbean cropping system.

Effect of weed management on physico-chemical property

Soil physico-chemical properties, *viz.* bulk density, soil pH, EC, OC and available N, P, K did not vary due to the weed management practices.

Weed density and dry weight in mungbean

Effect of tillage

Echinochloa colona was the dominant weed species in *Summer* mungbean. It is a C_4 plant and germinates when atmospheric temperature ranges from 30-40 °C temperature (Chouhan and Jonson, 2009) [31]. At the time of initial growth period of mungbean, maximum temperature varied from 37-40 °C which facilitated the germination of *E. colona* during summer. Further, the density and dry weight of *Echinochloa colona* was maximum when no tillage was done in fallow plots where mungbean was not grown after wheat under conventional tillage in both transplanted rice and wheat under CT(TPR)-CT(W)-fallow system followed by zero tillage in mungbean in absence of wheat residues under ZT+S(R)-ZT(W)-ZT(M) (T_3). However, the minimum density and dry weight of *E. colona* were found when zero tillage was done in mungbean in the absence of wheat residues under CT+S(R)-CT(W)-ZT(M) (Table 4). In CT(TPR)-CT(W)-fallow system, weeds grew on fallow land without any tillage operation on account of more weed seeds on the soil surface offer conventional tillage. Conventional tillage in the absence of preceding crop residues (T_1) facilitated germination due to soil pulverization during tillage. It also provided better seed-soil contact which enhanced germination and quick/ rapid growth of mungbean. As a consequence, weeds were suppressed due to smothering effect of mungbean. Our results corroborate the findings of Nath (2016) [11] under wheat-greengram cropping sequence.

Effect of weed Management

Among the different weed management practices adopted in rice and wheat, the maximum density and dry weight of *E. Colona* were recorded under weedy check plots at 45 DAS due to uninterrupted growth of weeds on account of non-adoption of weed control measures. However, density and dry weight of *E. Colona* were reduced under both the herbicidal treatments, either in regular use (W_2) or rotational use of herbicides (W_3). But significant difference did not exist between the treatments in terms of dry weight and density of *E. colona*. It might be due to the fact that all the herbicides which were applied in rice and wheat were physically removed out or decomposed by the microbial activity (Das, 2008) [3] and hence did not have any cumulative effect on weeds in mungbean and whatever. Reduction in *E. colona* density and dry weight occurred due to smothering effect of crop rather than residual/cumulative effect of herbicides applied in rice and wheat (Singh *et al*., 1996) [15].

Weed control efficiency in mungbean

Effect of tillage

Weed control efficiency was affected due to the tillage in mungbean. The lowest WCE was found under CT(TPR)-CT(W)-Fallow system (T_5) followed by zero tillage in mungbean in presence of wheat residues under ZT+S+MR(R)-ZT+RR(W)-ZT+WR(M) (T_4) being the maximum zero tillage in mungbean in absence of wheat residues under CT+S(R)-CT(W)-ZT(M) system (Table 4). However, in case of mungbean fallow plots after conventional tillage in transplanted rice and wheat under CT(TPR)-CT(W)-fallow system weeds were allowed to grow uninterrupted or zero inter-species (crop-weed) competition. Hence, the weeds attended maximum dry weight and exhibit lower weed control efficiency. However in case of CT+S(R)-CT(W)-ZT(M) lower weed density and dry weight were obtained, leading to higher weed control efficiency.

Effect of weed management

Weed control efficiency was affected due to weed management practices adopted in rice and wheat. The lower WCE was recorded when weeds were not controlled under weedy check plots as compared to herbicidal treated plots. *E. colona* produced higher dry matter due to unchecked growth in the weedy plots, whereas herbicidal treated plots resulted in reduced dry matter production due to smothering effect of mungbean. Therefore, herbicides treated plots registered higher WCE.

Effect of tillage on growth, yield attributes and yields of mungbean

It was remarkably noticed that, all the above parameters except root nodules, did not vary due to the cumulative effect of tillage practices adopted in rice and wheat. It shows that zero tillage in mungbean in presence or absence of wheat residues had similar effect on crop germination and emergence and tillage practices adopted in previous crops also did not affected the growth of mungbean. But, numbers of root nodules were significantly varied due to the tillage practices. Number of root nodules were minimum when zero tillage was done in mungbean in absence of wheat residues under CT+S(R)-CT(W)-ZT(M) (T_1) and these were slightly increased in ZT+S(R)-ZT(W)-ZT(M) and CT+S+MR(R)-CT+RR(W)-ZT+WR(M) being maximum when zero tillage was done in mungbean in presence of wheat residues under ZT+S+MR(R)-ZT+RR(W)-ZT+WR(M). Reason behind less number of nodules in CT+S(R)-CT(W)-ZT(M) might be that intensive tillage practices reduces microbial population and their activity by reversing carbon accumulation and breaking down soil structure. But in case of zero tillage, where previous crop residues were retained in hues quantity, had more organic carbon, which enhanced the microbial population and their activity and ultimately produced more nodules in pulses (Lupwayi *et al*., 2012) [8]. Thus, ZT+S+MR(R)-ZT+RR(W)-ZT+WR(M) had more numbers of nodules than other tillage practices.

Yield attributes had different trends. Minimum number of pods per plant were recorded when zero tillage was done in mungbean in presence of wheat residues under ZT+S+MR(R)-ZT+RR(W)-ZT+WR(M) being maximum when zero tillage was done in mungbean in absence of wheat residues under CT+S(R)-CT(W)-ZT(M). Chou and Lin (1976) [32] reported that rice residues release some allele-chemicals during decomposition, which hinders seed germination and emergence of succeeding crop. Consequently affected the growth of crop plants and finally had less numbers of branches under ZT+S+MR(R)-ZT+RR(W)-ZT+WR(M) system. Similarly, Shrestha *et al*. (2006) [33] also reported patchy crop emergence and poor crop growth due to the presence of previous crop residues under zero tillage. In case of CT+S(R)-CT(W)-ZT(M) weeds had minimum density and dry weight, which, facilitated less inter-species competition and in turn promoted more branching in mungbean. Seeds per pod and seed index were not affected due to the tillage practices, which did not affected the seed as well as haulm yield of mungbean.

Effect of weed management on growth, yield attributes and yields of mungbean

Plant population was not affected under different herbicidal treatments. It shows that there was not any persistence of residues of previous herbicides applied in rice and wheat. However, all the growth parameters and yield attributing traits were lower in weedy checks plots, because crop growth was hampered by weeds due to severe crop-weed competition. Whereas, these parameters were appreciably increased with regular application of same herbicides (W_2) and rotational application of herbicides (W_3) in rice and wheat. Herbicides treated plots had poor weed seed bank, which led to record lower density and dry weight of weeds. As a consequence of lower inter species competition, crop had quick and rapid growth and suppressed the post emerged weeds and finally produced, more branches per plant, pods and seeds per pod and ultimately recorded higher yields (Singh *et al*., 1996) [15].

Table 2: Effect of tillage and weed control practices on soil property in rice-wheat-mungbean cropping system

Treatments	Soil pH			Electrical conductivity (dS/m)			OC (%)			Bulk density (g/cc)		
	Initial	2014-15	2015-16	Initial	2014-15	2015-16	Initial	2014-15	2015-16	Initial	2014-15	2015-16
Tillage treatments												
T_1- CT+S(R)-CT(W)-ZT(M)	7.18	7.17	7.15	0.40	0.40	0.42	0.60	0.60	0.58	1.37	1.38	1.36
T_2 - CT+MR+S(R)-CT+RR(W)-ZT+WR(M)	7.16	7.15	7.13	0.39	0.40	0.41	0.60	0.61	0.63	1.37	1.35	1.34
T_3 - ZT+S(R)-ZT(W)-ZT(M)	7.13	7.11	7.09	0.37	0.38	0.39	0.61	0.63	0.65	1.37	1.37	1.40
T_4 - ZT+MR+S(R)-ZT+WR(W)-ZT+WR(M)	7.11	7.09	7.07	0.34	0.41	0.42	0.61	0.64	0.65	1.36	1.36	1.39
T_5 - CT(TPR)-CT(W)	7.19	7.18	7.16	0.37	0.36	0.39	0.60	0.60	0.59	1.38	1.39	1.41
SEm±	0.04	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.01
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.02
Weed management												
W_1	7.09	7.06	7.04	0.33	0.37	0.39	0.65	0.65	0.66	1.38	1.38	1.38
W_2	7.12	7.16	7.11	0.38	0.38	0.39	0.60	0.61	0.61	1.37	1.37	1.37
W_3	7.24	7.19	7.20	0.40	0.41	0.44	0.57	0.56	0.58	1.36	1.36	1.38
SEm±	0.04	0.03	0.05	0.03	0.03	0.02	0.03	0.02	0.02	0.01	0.01	0.01
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Effect of tillage and weed control practices on available N, P_2O_5 and K_2O of rice-wheat-mungbean cropping system

Treatment	N (kg/ha)			P_2O_5 (kg/ha)			K_2O (kg/ha)		
	Initial	2014-15	2015-16	Initial	2014-15	2015-16	Initial	2014-15	2015-16
Tillage practices									
T_1- CT+S(R)-CT(W)-ZT(M)	250.56	248.56	248.39	17.83	17.83	17.94	280.16	277.16	277.80
T_2 - CT+MR+S(R)-CT+RR(W)-ZT+WR(M)	250.78	249.67	250.11	18.03	18.23	18.26	280.89	283.19	285.45
T_3 - ZT+S(R)-ZT(W)-ZT(M)	253.33	251.89	252.00	18.05	18.57	18.38	285.93	286.81	293.33
T_4 - ZT+S+MR(R)-ZT+RR(W)-ZT+WR(M)	253.44	251.89	252.11	18.09	18.57	18.87	289.29	293.01	297.53
T_5 - CT(TPR)-CT(W)	250.22	248.22	248.11	18.79	18.60	17.99	276.00	288.01	287.17
SEm±	5.96	4.11	3.84	0.45	0.33	0.45	4.75	2.87	2.31
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weed management									
W_1	249.87	244.87	245.33	17.71	18.66	17.93	277.98	277.82	279.05
W_2	250.50	250.80	250.70	18.26	18.20	18.42	285.15	283.88	292.07
W_3	254.63	254.47	254.40	18.51	18.22	18.51	284.24	295.21	293.65
SEm±	2.77	2.12	2.09	0.24	0.21	0.22	3.51	2.84	2.09
CD (P=0.05)	NS	6.26	6.18	NS	NS	NS	NS	NS	NS

Table 4: Effect of tillage and weed dynamics, growth and yield attributes of mungbean

Tillage	Density *E. colona*/m²	Dry weight E. colona (g/m²)	WCE (%)	Plant height (cm)	Number of branches/plant	Root nodules/ plant	Pods/ plant	Seed yield (t/ha)
Tillage practices								
T_1- CT+S(R)-CT(W)-ZT(M)	2.59 (6.19)	2.61 (6.32)	71.84	30.26	3.11	55.07	11.57	1.17
T_2 - CT+MR+S(R)-CT+RR(W)-ZT+WR(M)	2.99 (8.46)	2.86 (7.71)	65.67	29.86	2.97	56.92	10.94	1.14
T_3 - ZT+S(R)-ZT(W)-ZT(M)	3.14 (9.36)	3.10 (9.11)	59.40	28.95	2.97	56.07	10.15	1.07
T_4 - ZT+MR+S(R)-ZT+WR(W)-ZT+WR(M)	3.19 (9.66)	3.36 (10.82)	51.83	28.26	2.89	60.14	9.66	1.01
T_5 - CT(TPR)-CT(W)	3.43 (3.43)	4.08 (16.12)	28.20	-	-	-	-	-
SEm±	0.19	0.44	-	0.91	0.10	1.22	0.41	0.05
CD (P=0.05)	0.61	1.44	-	NS	0.34	4.20	1.43	NS
Weed management								
W_1	4.13 (16.59)	4.39	16.46	27.34	2.74	64.81	8.56	0.80
W_2	2.49 (5.68)	2.42	67.21	29.61	2.99	55.50	10.84	1.23
W_3	2.58 (6.17)	2.80	76.16	31.65	3.23	49.84	12.34	1.27
SEm±	0.17	0.22	-	0.73	0.10	1.00	0.34	0.05
CD (P=0.05)	0.51	0.66	-	2.19	0.32	2.99	1.01	0.15

W_1- Weedy check,

W_2- Bispyribac 25 g/ha in rice and Clodinafop 60 g/ha + Sulfosulfuron 25 g/ha in wheat (during both the years)

W_3- Chlorimuron +metsulfuron-methyl (I st year) and Bispyribac 25 g/ha –(IInd year) in rice and Clodinafop 60 g/ha+2,4-D 0.5 kg/ha (Ist year) and Mesosulfuron +Idosulfuron methyl 12+2.4 g/ha –(IInd year) in wheat

Conclusions

Inclusion of mungben in summer in rice-wheat cropping system may be profitable option for obtaining higher crop yield with improved soil fertility and higher economic viability. Cultivation of summer mungbean under zero tillage after conventional tillage in both direct seeded rice and wheat with regular as well as rotational application of herbicides was the best option for getting higher yield and proper weed control but zero tillage with previous crop residues enhances the root nodulation due to higher microbial activity and increasing organic matter and nitrogen in soil which may give better response in term of profitability in future.

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