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Impact of integrated weed management and biofertilizers on growth and quality of *kharif* soybean [*Glycine max* (L.) Merill]

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Abstract
The experiment was conducted under field conditions at Agricultural College farm, Rajendranagar. Hyderabad, Telangana State during 2014-2015 and 2015-2016, to assess the effect of Bio-fertilizers and Integrated Weed Management (IWM) Practices on yield of soybean. The experiment was laid out in split-plot design with three replications. The main treatments were Five Integrated Weed Management (IWM) practices and the sub plot treatments were four Integrated Nutrient Management (INM) practices. The crop growth, and yield of soybean were significantly influenced by the weed management treatments. The plants were stunted with low height throughout the growth due to overcrowding of weeds that were not removed. The plants attained maximum height of 42.6 cm at harvest in 2014. The height was 43.6 cm in 2015.
Leaf area index is an important vegetative growth parameter. The pre emergence application of pendimethalin @ 1.0 kg a.i ha^{-1} increased the leaf area index of soybean seedlings. Maximum leaf area index developed at 60 days due to hand weeding at 25 and 45 days. There was no remarkable variation due to the integrated weed management treatment. Maximum dry weight of 4423 kg ha^{-1} was obtained in 2014 and 4533 kg ha^{-1} in 2015 due to hand weeding at 25 and 45 days after sowing.

Keywords: Integrated weed management practices, bio-fertilizers, growth and quality characters

Introduction
Soybean (*Glycine max* L.) is one of the most important oilseeds crops globally (Chaudhary *et al*., 2014). Soybean [*Glycine max* (L.) Merill] is a miracle golden bean of the 20th century. It occupies third place among oilseed crops of Telangana State. It is referred as wonder crop as it contains 40% good quality protein and 20% oil high in essential unsaturated fatty acids (Layek *et al*., 2014) [6]. In Telangana state, it is grown on 2.46 lakh hectares with production of 2.63 lakh tons and productivity of 1070 kg ha^{-1}. It is widely adopted in various cropping systems. Soybean is becoming popular in Southern Climatic Zone of Telangana. Inherent low levels of soil fertility status, population of crop beneficial microbes including rhizobium, phosphorus solubilising bacteria and potassium solubilising bacteria resource scarce situations are now recognized among the basic causes of low productivity. Improvements in biological nitrogen fixation can help to enhance soybean productivity per unit area. Weeds are a permanent constraint to crop productivity in agriculture. They are plants, which compete for nutrients, space, light, moisture and exert a lot of harmful effects by reducing the quality as well as quantity of the crop if the weed populations are left uncontrolled (Singh and Sheoran, 2008) [8]. Appropriate weed management practice is one of the most important components of improved production technology for obtaining higher crop yield with maximum benefit (Anwar *et al.*, 2004) [2]. In India, hand weeding is widely used for weed management and hoeing can be effective on older weeds, and remains selective, many mechanical control methods become difficult after the cotyledon stage and their selectivity decreases with increasing crop and weed age (Verma *et al*., 2015) [10]. It is a laborious, time consuming and expensive method. Use of suitable herbicide provides more effective and efficient weed control. The crop is highly sensitive to early weed infestation during the seedling stage and the critical crop-weed competition during 3-4 weeks after sowing (Jha *et al*., 2014) [5]. Hand weeding and blade harro

are traditionally practiced to ward off the weeds, loosen the soil for good aeration and conserve the moisture. The herbicides are apprehended to have direct or indirect consequences on non-targeted organisms including soil micro flora in the field. Hence, the present investigation was undertaken to study the bio-efficacy of herbicide combinations and bio-fertilizer management.

Material and methods

A field study was conducted at Agricultural College Farm, Rajendranagar, Hyderabad, Telangana state during cropping season of 2014 and 2015.The soil was sandy loam in texture having 7.8 pH and EC 0.21 d S m^{-1}. It was very poor in nutrient status with 0.35% OC and 226 kg ha^{-1} available N, available P was 18 kg $ha^{-1}$and available K was 236 kg ha^{-1}. The layout was a split plot design. The main treatments were : (W1) Pre-emergence application of pendimethalin @ 1.0 kg a.i ha^{-1} followed by hand weeding 25 DAS, (W2) Pre emergence application of pendimethalin @1.0 kg a.i ha^{-1} followed by post-emergence application of imazethapyr @ 100 g a.i ha^{-1}+ quizalofop-p-ethyl @ 50 g a.i ha^{-1} 25DAS, (W3) Pre-emergence application of pendimethalin @1.0 kg a.i ha^{-1} followed by post-emergence application of odyssey i.e. imazethapyr + imazamox @ 70 g a.i ha^{-1} at 25 DAS, (W4) Hand weeding at 25 and 45 DAS and (W5) un-weeded check. The sub plot treatments comprising of (F1) Recommended dose of fertilizers @ 30:60:40 kg ha^{-1} NPK, (F2) RDF+ seed treatment with rhizobium @ 250g 10kg^{-1}seed, (F3) RDF +seed treatment with rhizobium @ 250g 10kg^{-1} seed + phosphate solubilizing bacteria @ 5 kg ha^{-1}, (F4) RDF + seed treatment with rhizobium @ 250 g10 kg^{-1} seed + phosphate solubilising bacteria @ 5 kg ha^{-1} + potassium solubilising bacteria @ 5kg ha^{-1}. Recommended fertilizer dose of 30:60:40 kg ha^{-1} NPK was calculated for the dimensions of each sub plot and applied at the time of sowing in the form of urea. Single super phosphate and muriate of potash. Seed rate was @ 63 kg ha^{-1}. The bio-fertilizers *brady rhizobium japonica* were mixed as per the treatment in jaggery solution prepared @ 250 g for 10 kg seed. The seed was thoroughly mixed with the solution and shade dried. The Phosphorus solubilising bacteria and potassium solubilising bacteria were applied @ 5 kg ha^{-1} after mixing with FYM. The seeds were dibbled at the rate of two per hill 10 cm apart in 30cm interval. The crop was sown on 10th July in 2014 and 18th June in 2015.A pre emergence herbicide (Pendimethalin 30%EC) was applied on next day of sowing and post emergence application of (imazethapyr 10% SL, Quizalofop-p-ethyl 5% EC and odyssey) was done 25 DAS with the help of knapsack sprayer fitted with flat fan nozzle. The protein content in soybean seeds ranged from 40.1 to 41.9 per cent. There was no significant variation due to the weed management treatments and bio fertilizes or their interaction. The experimental data was subjected to statistical test by following analysis of variance technique suggested by Panse and Sukhatme (1978) [7].

Results and discussions

Crop growth and quality

The competition increased with age of the crop. In spite of weeding at 45 days after sowing the plant height reduced by 35% in the un-weeded crop in the first year and by 31% in the second year. At harvest the reduction in height of soybean was 30% in 2014 and 29% in 2015 compared to the crop given weeding twice at 25 and 45 days after sowing. Reduction in plant height of soybean due to competition with weeds relative to hand weeding and cultural operations was also reported by Wadafale *et al.* (2011) [11]. This effect was consistent in 2014 and 2015. Chamate *et al*. (2012) observed the usefulness of pre emergence application of pendimethalin @ 1.0 kg a.i ha^{-1} and hoeing at 40 days. They reported that there was no effect of this herbicide on the plant height of soybean at 20 days age of the crop.

At harvest, there was no significant difference in leaf area index of the crop growing freely without checking the weeds and the weed management treatments. This is an expected phenomenon since the crop senesce and shed leaves at maturity.

Soybean is rich in protein among different pulse crops. The data on protein content in response to different treatments is presented in table. The protein content ranged from 40.1 to 41.0 per cent in seed during the first year and from 40.1 to 41.3 per cent in the second year. The cultural and herbicide application methods of weed management did not influence the protein per cent significantly. Singh *et al.* (2014) [9] also did not observe significant variation in protein percentage of the seed due to cultural or herbicide treatments. But, Chamate *et al*. (2002) [3] recorded significant improvement in the protein content of soybean seed in response to the integrated weed management. The pre-emergence application of pendimethalin @ 1.0 kg *a.i* ha^{-1} or pre plant incorporation of fluchloralin @ 1.0 kg *a.i* ha^{-1} followed by 1 hoeing at 40 days or 2 hoeings at 25 and 40 DAS increased the protein per cent compared to 1 weeding at 25 days and 1 hoeing at 40 DAS. Maximum dry weight of 4423 kg ha^{-1} was obtained in 2014 and 4533 kg ha^{-1} in 2015 due to hand weeding at 25 and 45 days after sowing. The dry matter production was significantly low in the integrated weed management and the application of pre and post emergence herbicide treatments compared to hand weeding during the 2 years. Angiras *et al.* (1995) [1] also observed that the pre sowing incorporation, pre or early post emergence application of imazethapyr significantly reduced the dry weight of weeds with every increment of 50 up to 200 g a.i ha^{-1}.

Table 1: Growth Parameters as influenced by weed management treatments and bio-fertilizers during 2014 and 2015

Treatment	Plant height (cm)		Leaf area Index		Dry matter production	
Weed management	2014	2015	2014	2015	2014	2015
W1:PE Pendimethalin @ 1kg *a.i* ha^{-1}fb Hand weeding 25 DAS	41.2	42.2	2.58	2.51	3,911	3,922
W2:PE Pendimethalin @ 1kg *a.i* ha^{-1}fb PoE Imazethapyr @100 g *a.i* ha^{-1}+ Quizalofop -P-ethyl @ 50 g *a.i* ha^{-1}25 DAS	38.7	39.7	2.38	2.23	2,859	2,891
W3:PE Pendimethalin @ 1kg *a.i* ha^{-1}fb PoE Imazethapyr + Imazamox@70 g *a.i* ha^{-1}25 DAS	38.5	39.4	2.38	2.47	3,043	3,043
W4: Hand weeding 25 and 45 DAS	42.6	43.6	2.67	2.70	4,423	4,533
W5: Unweeded check	30.0	31.0	2.00	2.16	2,068	2,044
SE±	1.8	1.8	0.30	0.28	178	201
CD (P=0.05)	4.3	4.3	NS	NS	417	470
Bio-fertilizers						

F1: Fertilizers @ 30:60:40 kg ha^{-1} N:P_2O_5:K_2O	37.1	38.1	2.33	2.18	3,236	3,229
F2: F1+ Rhizobium @ 250 g10 kg^{-1} seed	38.5	39.5	2.32	2.16	3,238	3,252
F3: F2+ Phosphate solubilising bacteria @ 5 kg ha^{-1}	38.0	39.0	2.40	2.17	3,276	3,296
F4: F3+ Potassium solubilising bacteria @ 5 kg ha^{-1}	39.1	40.1	2.56	2.24	3,293	3,369
SE±	1.4	1.4	0.09	0.09	291	280
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Weed management Bio-fertilizers						
SE±	3.2	3.2	0.20	0.25	569	625
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 2: Protein percent in seed as influenced by weed management treatments and bio-fertilizers during 2014 and 2015

Treatment	**Protein%**	
	2014	**2015**
Weed management		
W1:PE Pendimethalin @ 1kg *a.i* ha^{-1}fb Hand weeding at 25DAS	40.8	41.3
W2:PE Pendimethalin @ 1kg *a.i* ha^{-1}fb PoE Imazethapyr @100g *a.i* ha^{-1} +Quizalofop- P-ethyl @ 50g *a.i* ha^{-1}25DAS	40.1	40.9
W3:PE Pendimethalin @ 1kg *a.i* ha^{-1}fb PoE Imazethapyr + Imazamox@ 70 g *a.i* ha^{-1}25DAS	40.7	41.3
W4: Hand weeding at 25 and 45DAS	41.0	41.2
W5: Unweeded check	40.2	40.1
SE±	0.6	0.2
CD(P=0.05)	NS	NS
Bio-fertilisers		
F1: Fertilizers @ 30:60:40 kg ha^{-1} N:P_2O_5:K_2O	40.5	40.5
F2:F1 + Rhizobium @ 250 g10 kg^{-1} seed	40.1	41.4
F3:F2 + Phosphate solubilising bacteria @ 5 kg ha^{-1}	40.6	41.0
F4:F3+ Potassium solubilising bacteria @ 5 kg ha^{-1}	41.1	41.4
SE±	1.0	0.8
CD(P=0.05)	NS	NS
Weed Management x Bio-fertilizers		
SE±	2.3	1.9
CD(P=0.05)	NS	NS

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