Original Research Article

Effect of different PPI herbicides on energy utilization, nutrient content and uptake of soybean (*Glycine Max* L.)

Abstract:

A field experiment was carried out during *Kharif* 2019-20 at Jawaharlal Nehru Krishi Vishwa Vidyalaya's BSP Unit, Department of Agronomy, Jabalpur (M.P.). Using a Randomized Block Design, eleven weed control treatments in all were set up with three replications. The BSP Unit, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) was the site of a field experiment in Kharif 2019–20. Using a Randomized Block Design, eleven weed control treatments in all were set up with three replications. The study's findings showed that Diclosulam 0.9% + Pendimethalin 35% SE at 45 + 1750 g ha^{-1}had the highest levels of N, P, and K. The weedy check plot had the lowest N, P, and K content. Comparing hand weeding to all other treatments, the highest uptake of N, P, and K was noted. The combination of Diclosulam 0.9% + Pendimethalin 35% SE 22.5 + 875 gha^{-1}showed the highest uptake of N, P, and K. Among the several herbicidal treatments, Diclosulam 0.9% + Pendimethalin 35% SE 22.5 + 875 g ha-1 (134.80 lakh k cal ha^{-1}) was the crop that used the most energy, followed by Diclosulam 0.9% + Pendimethalin 35% SE45 + 1750 g ha^{-1} (134.20 lakh k cal ha^{-1}). Utilizing Diclosulam 0.9% + Pendimethalin 35% SE22.5 + 875 g ha^{-1}, the grain's utilization of energy was measured. The weed treatments in the weedy check plot used the most energy (270.68 lakh k cal ha^{-1}). Hand weeding plot was shown to use the least amount of energy (2.12 lakh k cal ha^{-1}).

Keywords:Nutrient content, uptake, energy utilization, herbicides, weed and soybean

1. Introduction:

A significant leguminous oilseed crop in the nation, soybeans (*Glycine max* (L.) merrill) provide over 50% of oilseeds and over 30% of the nation's entire supply of vegetable oils (Tiwari, 2006). Tropical and subtropical climates are ideal for the crop's growth. The 21st century's "Miracle Crop," "Wonder Crop," or "Golden Bean" is the soybean. It originated in China and was brought to India from the United States in 1968. In addition to its nutritional value, soybeans may fix atmospheric nitrogen at a rate of 65–115 kg ha^{-1} $year^{-1}$ through symbiosis with *Bradyrhizobium japonicum* (Alexander, 1977). The first 30 days following soybean planting are crucial for weed-crop competition. Soybean being a rainy season crop is heavily infested with many grasses and broad leaf weeds. Weed infestation is considered a persistent and complex constraint in soybean, as it influences growth and development of soybean through competition for nutrients, water, light and space as well as through production of allelopathic compounds (Vollmann et al. 2010). However, losses in crop yield varies depending on intensity and weed species involved.This highly nutritious crop is very helpful in meeting the nutritional needs of the growing population, but because it is a rainy season crop, soybeans are severely impacted by weed competition in the early stages of crop growth. Depending on the type, intensity, and duration of weed competition, this can result in a loss of 40–60% of the potential yield. Additionally, each hectare, weeds deplete the soil of 30–60 kg of nitrogen, 8–10 kg of phosphorous, and 40–100 kg of potash (Mishra et al., 2002). The application of herbicides enhanced crop productivity, reduced weeds, and freed up labor for other beneficial purposes. Herbicides by themselves cannot control weeds during the growing season. In order to reduce the amount of herbicide that needs to be sprayed to the soil in conjunction with mechanical weeding, a combination of several weed management techniques is the ideal approach. This will assist to manage weeds in the most effective manner to maintain and increase soybean production.

2. Material and Methods

Within the parameters of the topic being studied, the current study, "Efficacy of pre plant incorporation of herbicides on weed management, crop growth, and yield of soybean," was designed and conducted. The crop season's average rainfall (1350 mm) and temperature (minimum and maximum mean temperatures between 10.3^0C and 25^0C and 27.1^0C and 34.9^0C, respectively) were nearly ideal for soybean growth and development. Therefore, it might be said that early crop growing periods with less rainfall had a slight impact on agricultural productivity. These are the treatments details, $T_{1:}$ Diclosulam 0.9% + Pendimethalin 35% SE@ 18 + 700, T_2: Diclosulam 0.9% + Pendimethalin 35% SE@ 20.25 + 787.5, T_3: Diclosulam 0.9% + Pendimethalin 35% SE@ 22.5 + 875, T_4:

Diclosulam 0.9% + Pendimethalin 35% SE@ 45+1750, T_5: Diclosulam 84 % WG @ 20.25, T_6: Diclosulam 84 % WG @ 22.50, T_7: Pendimethalin 30 % EC @ 787.5, T_8: Pendimethalin 30 % EC @ 875, T_9: Pendimethalin 30 % EC+ Imazethapyr 2 % EC 900 + 60 (g/ha) in each herbicidal treatments, T_{10}: Hand weeding (Twice) and T_{11}: Weedy check.

Comment [MS1]: Maintain the uniformity in the entire manuscript. Use g/ha or g ha^{-1}

2.1 Energy utilization by weeds and crop

The energy consumption of crops and weeds was established following Leith (1965). The energy level, according to him, was 4.30,000 calories per gram of dry weight marijuana. Goplan*et al.* (1971) found that soybean seed had an energy content of 4.35 kcal per gram. The energy content of the dry weights was calculated using these data.

Comment [MS2]: Maintain the uniformity,

2.2 Nutrient content in plant sample

2.2.1 Digestion of samples

Following conventional procedures, the plant samples were wet digested to determine the nutritional content of the seed and stover (1)

Table 1. Methods used for determination of nutrient content in plant

Nutrient	Analytical method	Method employed
Nitrogen	Micro – Kjeldahl method	AOAC (1995)
Phosphorus	Vanadomolybdate yellow colour method	Bhargava &Raghupathi (1984)
Potassium	Flame-photometric method	Bhargava &Raghupathi (1984)
Sulphur	Turbidimetric method	Bhargava &Raghupathi (1984)

2.2.2Nutrient uptake (kg ha^{-1})

The following formula was used to determine the soybean's nutrient intake in kg ha-1 in relation to the yield in kg ha-1 of dry matter production.

$$\text{Nutrient uptake (kg ha}^{-1}) = \text{Nutrient content (\%) X yield (kg ha}^{-1})$$

2.3 Statistical analysis

The usual procedure was used to tabulate and statistically evaluate the data related to each crop attribute. According to Gomez and Gomez (1984), analysis of variance for randomized block design and the importance of treatments were examined in order to get reliable results. The 'F' test of significance was used to examine the differences in treatment means based on the null hypothesis. The standard error of mean (SEm±) and critical differences (CD) were computed and interpreted for explaining the results if the variance ratios (F-test) were determined to be significant at the 5% level of significance.

Table. 2: Skeleton of analysis of variance (ANOVA) is given below

Source of variation	d. f.	S. S.	M. S. S.	"F"cal.	
				5%	1%
Replications(r-1)	2				
Treatment(t-1)	10				
Error(r-1)(t-1)	20				
Total(rt-1)	32				

S. Ed. = SEm x √2 CD = SEd X t 5 % for error d.f

Whereas,

S. Em = Standard error of treatment means

S.Ed = Standard error of difference between treatment means

C. D. = Critical difference

r =Number of replications

edf = Error degree of freedom

3. Results and Discussion

3.1 Effect of treatments on energy utilization by weeds and crop

The information on crop and weed energy use as a function of treatment is provided in Figure 1 and Table 3. Among the treatments, hand weeding used the most energy from the crop (136.30 lakh k cal ha^{-1}). A comparison of the various herbicidal treatments revealed that Diclosulam 0.9% + Pendimethalin 35% SE 22.5 + 875 g ha^{-1} (134.80 lakh k cal ha^{-1}) used the most energy, followed by Diclosulam 0.9% + Pendimethalin 35% SE45 + 1750 g ha-1 (134.20 lakh k cal ha-1). The crop used the least amount of energy in the control group (122.70 lakh kcal ha-1); this could be because of weed competition.Due to less weed competition in the field, Diclosulam 0.9% + Pendimethalin 35% SE22.5 + 875 g ha-1 was used to record the energy used by the grain (78.78 lakh k cal ha-1) and

Formatted: Superscript

Formatted: Superscript

Formatted: Superscript

Comment [MS3]: Please use ha^{-1} in the entire manuscript.

Diclosulam 0.9% + Pendimethalin 35% SE45 +1750 g ha-1 (70.08 lakh k cal ha-1). The weedy check plot (39.47 lakh k cal ha-1) had the lowest grain energy utilization, which may have been caused by the plot's higher weed density. The maximum weed density in the weedy check plot resulted in the highest energy used by the weed (270.68 lakh kcal ha-1), and similar patterns were seen with other treatments. When weeding by hand, the least amount of energy was used (2.12 lakh k cal ha-1).

Table 3.Energy utilization by crop, weed and grain (lakh k cal ha^{-1})

Comment [MS4]: Add SEm and CD Value in the table

Treatment		Dose g/ha	Crop	Grain	Weeds
T_1	Diclosulam 0.9% + Pendimethalin 35% SE	18 + 700	134.00	59.13	10.68
T_2	Diclosulam 0.9% + Pendimethalin 35% SE	20.25 + 787.5	134.10	60.90	9.50
T_3	Diclosulam 0.9% + Pendimethalin 35% SE	22.5 + 875	134.80	78.78	4.98
T_4	Diclosulam 0.9% + Pendimethalin 35% SE	45 + 1750	134.20	70.08	3.00
T_5	Diclosulam 84 % WG	20.25	133.80	58.81	11.52
T_6	Diclosulam 84 % WG	22.50	134.00	59.21	10.78
T_7	Pendimethalin 30 % EC	787.5	133.80	59.37	11.90
T_8	Pendimethalin 30 % EC	875	133.90	59.53	13.50
T_9	Pendimethalin 30 % EC +Imazethapyr 2 % EC	900 + 60	133.80	57.19	18.23
T_{10}	Hand weeding	20 & 40 DAS	136.30	89.52	2.12
T_{11}	Weedy check	-	122.70	39.47	270.68

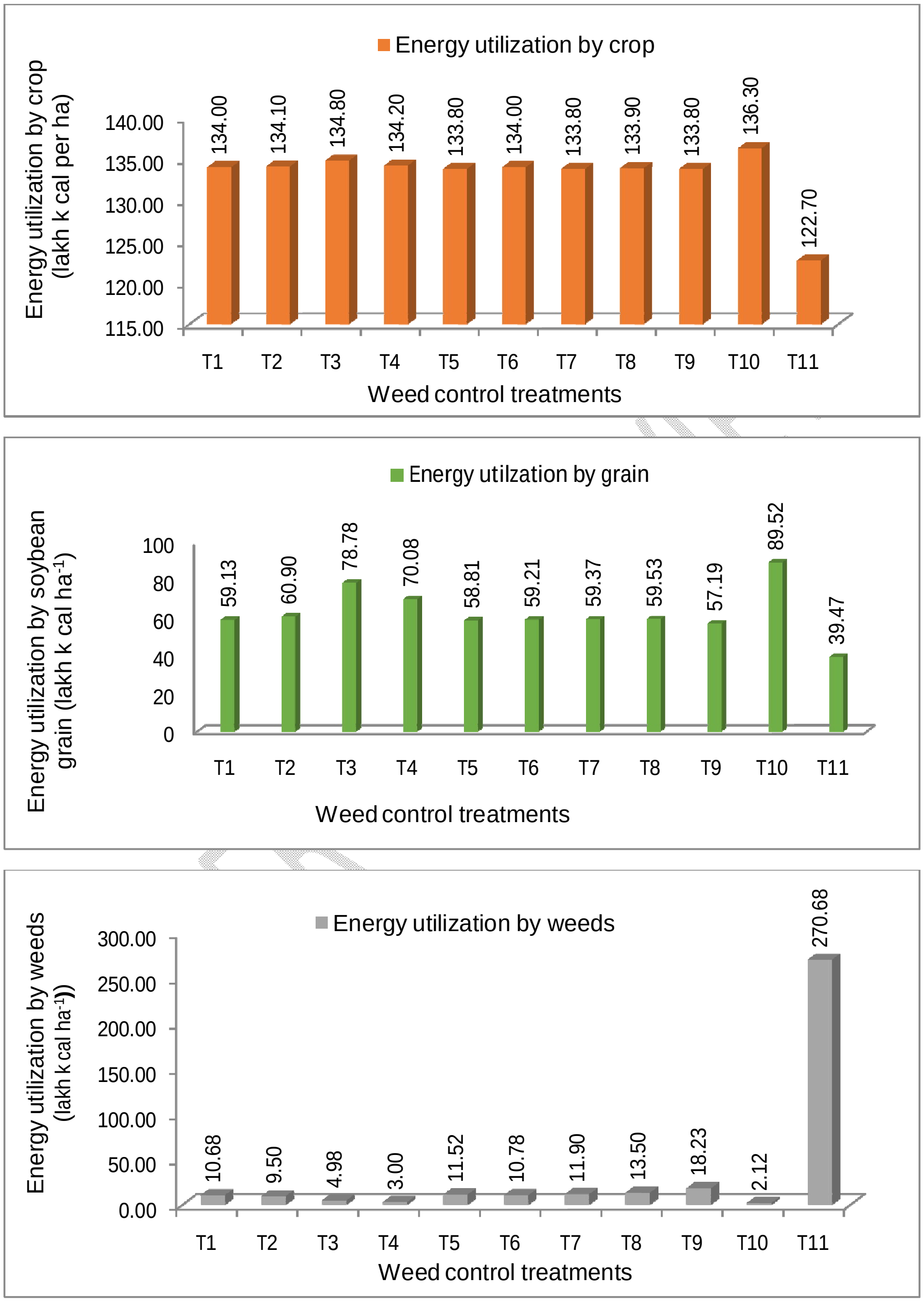

Fig.1Energy utilization by crop biomass, grain and weeds (lakh k cal ha^{-1})

3.2 Effect of treatments on nutrient content in soybean

3.2.1 Nutrient content in seed

According to the findings in Table 4 and the graphic representation in Figure 2, the hand-weeded (6.30%) treatment had the maximum N content in soybean seed, while the weedy check (5.50%) had the lowest values. Among the herbicidal treatments, Diclosulam 0.9% + Pendimethalin 35% SE45 + 1750 g ha-1 had the highest N content in soybean seed (6.10%) due to the lowest weed density. In comparison to the control, the nitrogen content of the seed was much higher in all treatments. Next came Diclosulam 0.9% + Pendimethalin 35% SE45 + 1750 g ha-1 (0.27%), which caused the P content in the seed to increase from 0.21% in the weedy control to 0.28% in the hand-weeded treatment. In comparison to the control, the P content of the seed was considerably greater in all treatments. While weedy check had the lowest K content (1.14%), hand weeding had the greatest K content (1.36%). Due to low weed density, the soybean seed treated with Diclosulam 0.9% + Pendimethalin 35% SE45 + 1750 g ha-1 (1.31%) had the highest K content.Similar findings found with Prachand*et al.* (2015)

3.2.2 Nutrient content in stover

According to the results in Table 4, which is visually shown in Figure 3, the hand-weeded treatment had the highest N concentration in stover (3.15%), while the weedy check had the lowest (2.25%). In comparison to control, the stover's nitrogen level was noticeably greater in all treatments. The stover's N content increased from 2.98 to 3.11 in Diclosulam 0.9% + Pendimethalin 35% SE 18 + 700 to 45 + 1750 g ha-1, respectively. In terms of stover P content, the herbicidal treatments Diclosulam 0.9% + Pendimethalin 35% SE 45 + 1750 g ha-1 (0.18%) had the highest P content, whereas the weedy check had the lowest value (0.12%).Throughout the treatment, the hand weeding treatment had the highest P concentration (0.19%). In a similar vein, hand-weeded plants had the highest K content (2.39%), whereas control plants had the lowest value (1.82%). The herbicidal treatments with the highest K content were Diclosulam 0.9% + Pendimethalin 35% SE 45 + 1750 g ha-1 (2.33%) and Diclosulam 0.9% + Pendimethalin 35% SE 22.5 + 875 g ha-1 (2.31%). In all treatments, the stover's potassium level was noticeably higher than the control. These findings correlated with Jha *et al.* (2012)

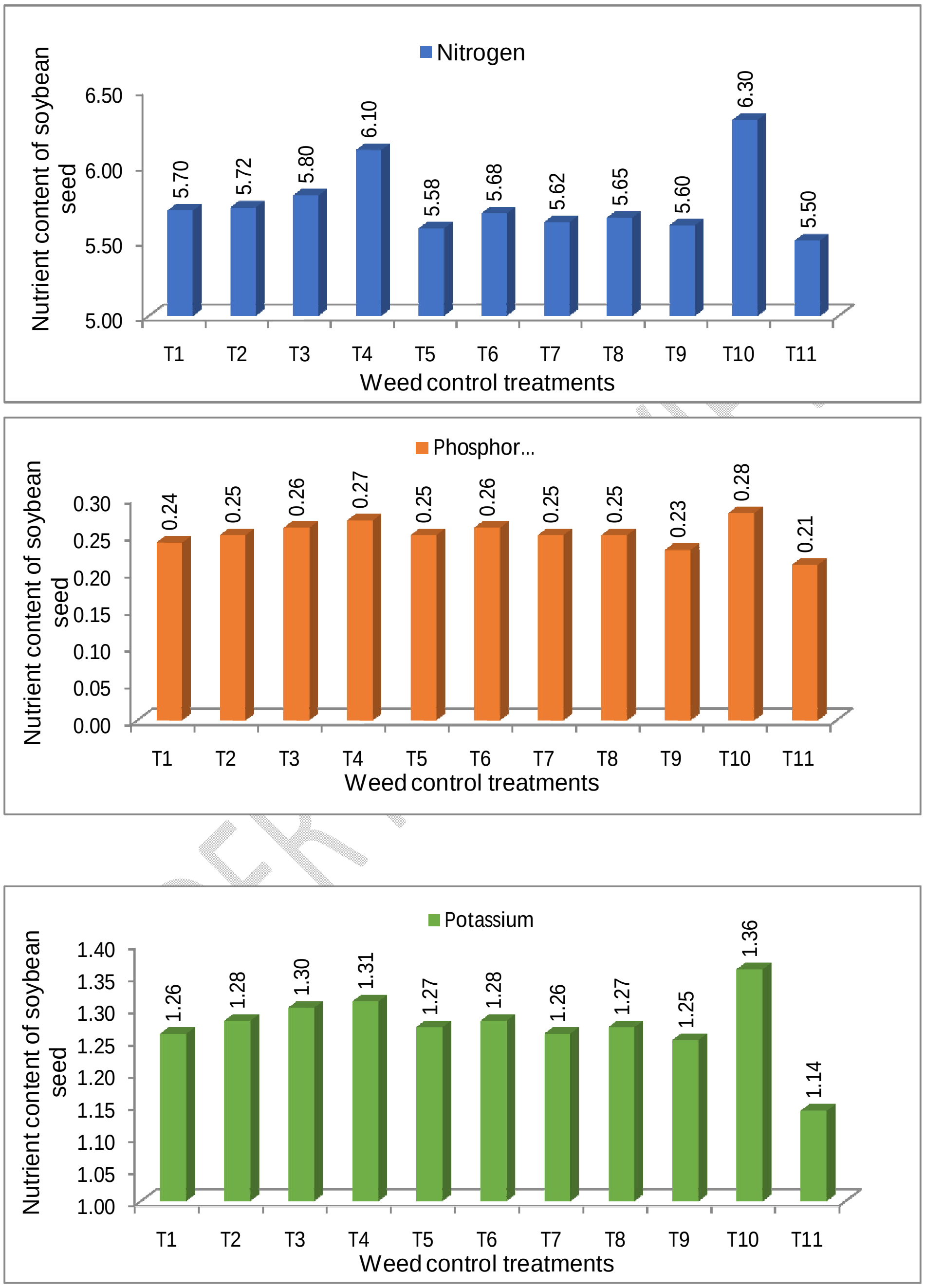

Fig.3Effect of treatments on nutrient content of soybean seed

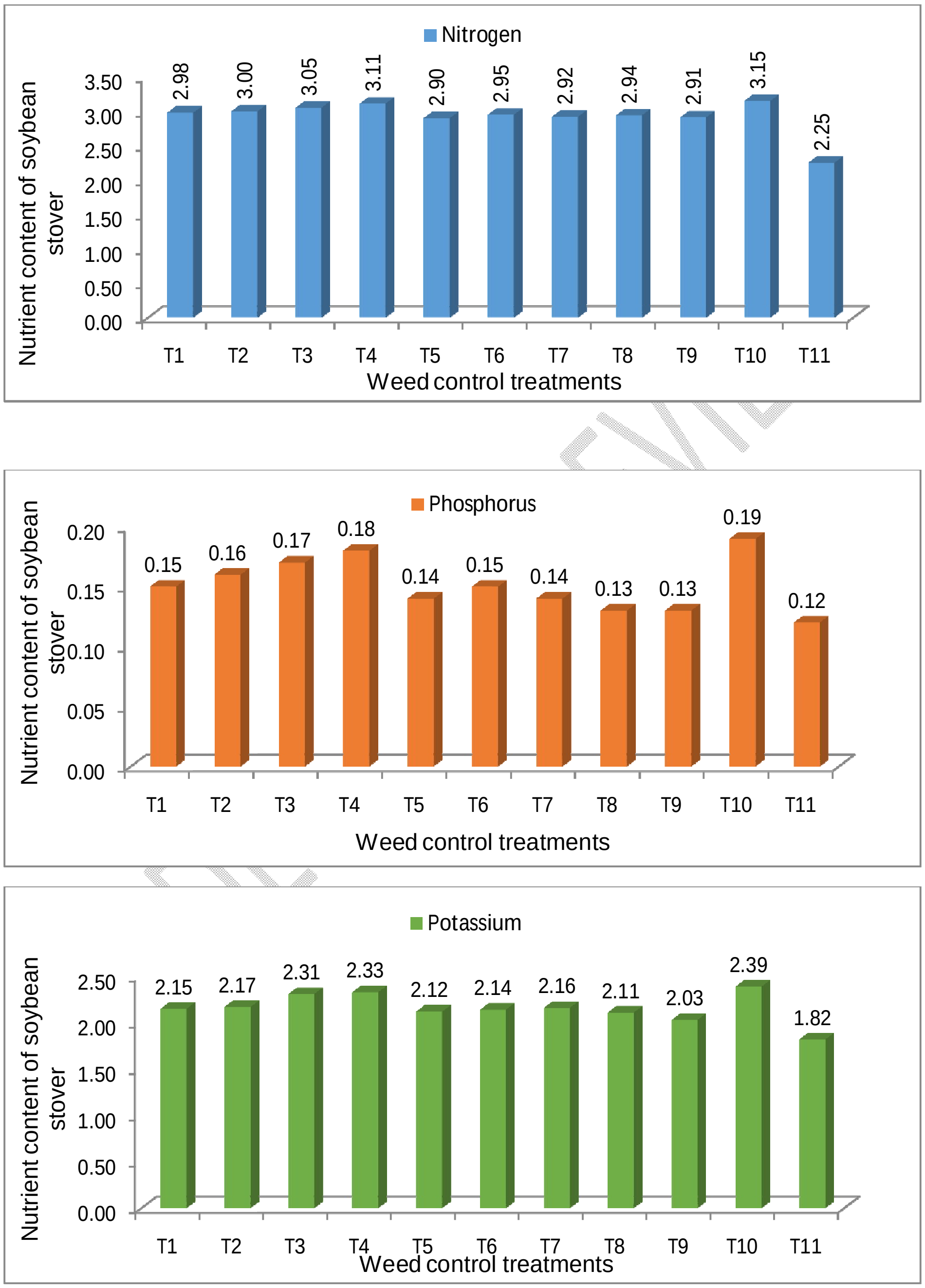

Fig.4 Effect of treatments on nutrient content of soybean stover

Table 4. Effect of treatments on nutrient content of soybean seed and stover

Treatments		Dose g ha^{-1}	Nutrients content (%)					
			Nitrogen		Phosphorus		Potassium	
			Seed	Stover	Seed	Stover	Seed	Stover
T_1	Diclosulam 0.9% + Pendimethalin 35% SE	18 + 700	5.70	2.98	0.24	0.15	1.26	2.15
T_2	Diclosulam 0.9% + Pendimethalin 35% SE	20.25 + 787.5	5.72	3.00	0.25	0.16	1.28	2.17
T_3	Diclosulam 0.9% + Pendimethalin 35% SE	22.5 + 875	5.80	3.05	0.26	0.17	1.30	2.31
T_4	Diclosulam 0.9% + Pendimethalin 35% SE	45 + 1750	6.10	3.11	0.27	0.18	1.31	2.33
T_5	Diclosulam 84 % WG	20.25	5.58	2.90	0.25	0.14	1.27	2.12
T_6	Diclosulam 84 % WG	22.50	5.68	2.95	0.26	0.15	1.28	2.14
T_7	Pendimethalin 30 % EC	787.5	5.62	2.92	0.25	0.14	1.26	2.16
T_8	Pendimethalin 30 % EC	875	5.65	2.94	0.25	0.13	1.27	2.11
T_9	Pendimethalin 30 % EC +Imazethapyr 2 % EC	900 + 60	5.60	2.91	0.23	0.13	1.25	2.03
T_{10}	Hand weeding	20 & 40 DAS	6.30	3.15	0.28	0.19	1.36	2.39
T_{11}	Weedy check	-	5.50	2.25	0.21	0.12	1.14	1.82

3.3 Nutrient uptake by soybean

3.3.1 Nutrient uptake by seed

The data present in Table 5 and illustrated visually in Figure 5.The impact of Diclosulam 0.9% + Pendimethalin 35% SE, check herbicide, weed-free, and hand-weeded plots on crop nutrient uptake showed a significant range, which amply demonstrated how varied herbicide dosages affected crop production and growth. Following Diclosulam 0.9% + Pendimethalin 35% SE45 + 1750 g ha-1 (98.28.10, 4.35, and 21.11 kg ha-1), the treatment with the highest uptake was Diclosulam 0.9% + Pendimethalin 35% SE22.5 + 875 g ha-1 (105.04, 4.71, and 23.54 kg ha-1). The hand weeding treatment had the highest uptake of N, P, and K by soybean seed (129.65, 5.76, and 27.99 kg ha-1). The control plot showed the lowest seed absorption of N, P, and K (49.91, 1.91, and 10.34). In comparison to the control, soybeans absorbed more nutrients overall across all treatments. This might be due to the usage of pesticides may have contributed to the crop's increased nutrient uptake and decreased weed clearance of those nutrients (Jha et al., 2012). These conclusion corelated with the findings of Prachand*et al.* (2015)

Comment [MS5]: Mention the unit

3.3.2 Nutrient uptake by stover

The findings showed that the crop's uptake of nutrients increased proportionately with successively higher herbicide dosages. Accordingly, the biomass yield generated was correlated with the intake of N, P, and K stover (Table 5 and graphically shown in Figure 6), with the hand-weeded treatment exhibiting the highest uptake (101.97, 6.15, and 77.37 kg ha-1). The control plot had the lowest stover uptake of N, P, and K. The uptake of N in stover raised from 78.31 to 97.83 kg ha-1 in Diclosulam 0.9% + Pendimethalin 35% SE18 + 700to 22.5 + 875 g ha-1. Similar findings have been reported by Jha et al. (2012) and Pandya et al. (2005).

Table 5. Effect of treatment on nutrient uptake (kg/ha) by soybean

Treatments		Dose g/ha	Nitrogen			Phosphorus			Potassium		
			Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total
T_1	Diclosulam 0.9% + Pendimethalin 35% SE	18 + 700	77.48	78.31	155.79	3.26	3.94	7.20	17.13	56.50	73.63
T_2	Diclosulam 0.9% + Pendimethalin 35% SE	20.25 + 787.5	80.08	83.72	163.80	3.50	4.47	7.97	17.92	60.56	78.48
T_3	Diclosulam 0.9% + Pendimethalin 35% SE	22.5 + 875	105.04	97.83	202.87	4.71	5.45	10.16	23.54	74.09	97.63
T_4	Diclosulam 0.9% + Pendimethalin 35% SE	45 + 1750	98.28	95.78	194.06	4.35	5.54	9.89	21.11	71.76	92.87
T_5	Diclosulam 84 % WG	20.25	75.43	75.13	150.56	3.38	3.63	7.01	17.17	54.92	72.09
T_6	Diclosulam 84 % WG	22.50	77.31	84.18	161.49	3.54	4.28	7.82	17.42	61.07	78.49
T_7	Pendimethalin 30 % EC	787.5	76.70	81.06	157.76	3.41	3.89	7.30	17.20	59.96	77.16
T_8	Pendimethalin 30 % EC	875	77.32	79.54	156.86	3.42	3.52	6.94	17.38	57.09	74.47
T_9	Pendimethalin 30 % EC +Imazethapyr 2 % EC	900 + 60	73.63	80.83	154.46	3.02	3.61	6.63	16.44	56.39	72.83
T_{10}	Hand weeding	20 & 40 DAS	129.65	101.97	231.62	5.76	6.15	11.91	27.99	77.37	105.36
T_{11}	Weedy check	-	49.91	51.37	101.28	1.91	2.74	4.65	10.34	41.56	51.90

Comment [MS6]: Mention the unit

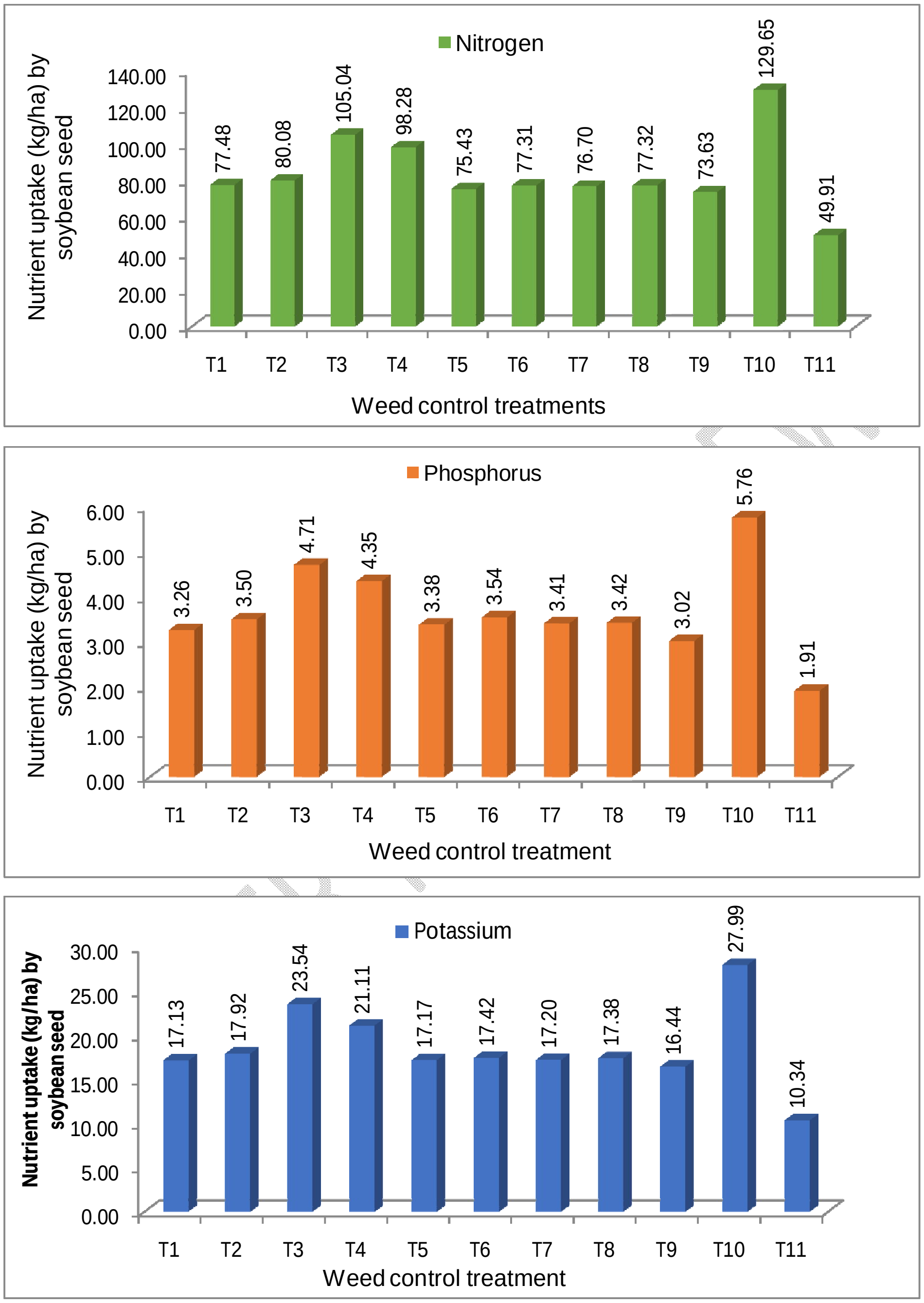

Fig.5Effect of treatment on nutrient uptake (kg/ha) by soybean seed

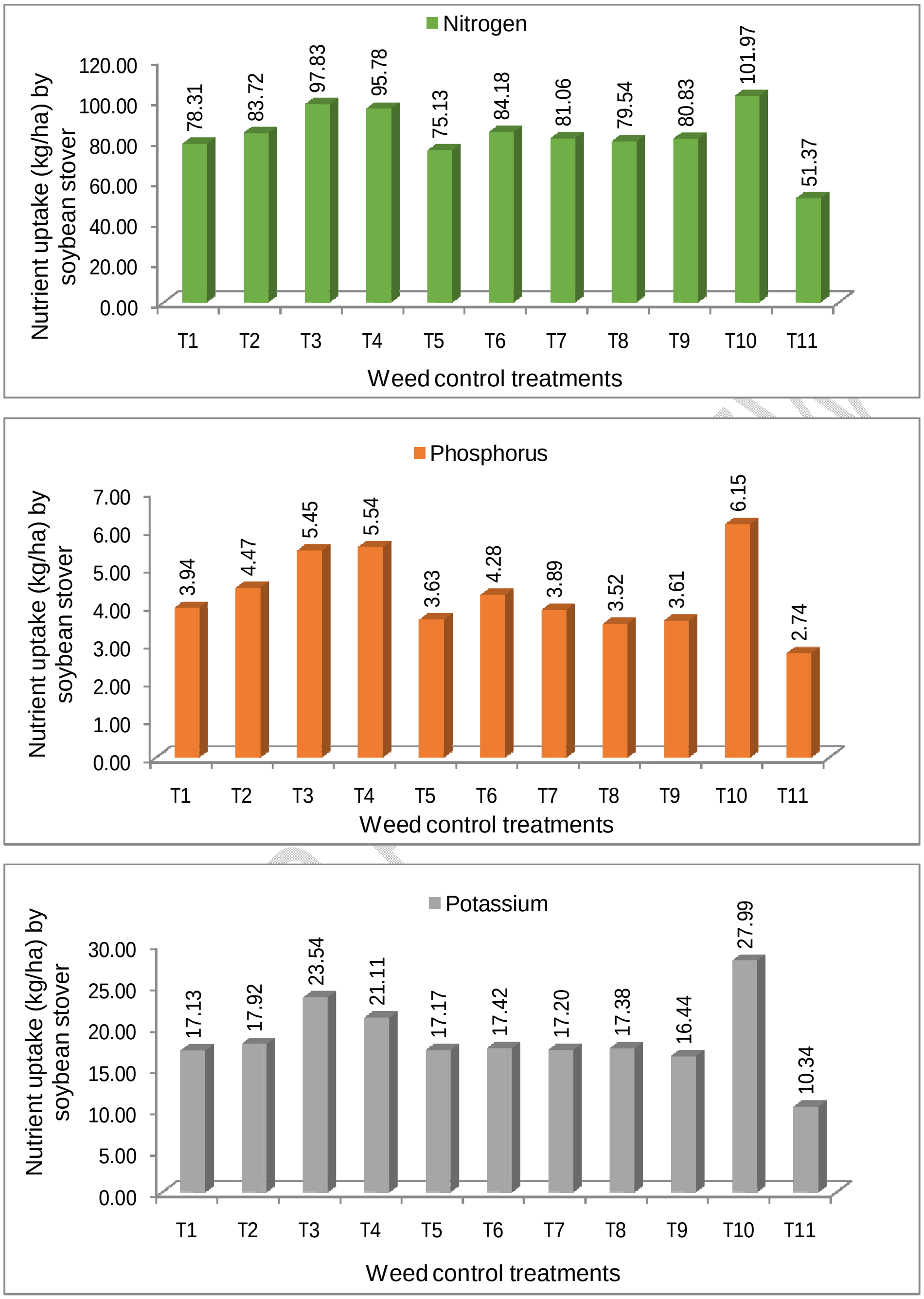

Fig.6 Effect of treatment on nutrient uptake (kg/ha) by soybean stover

4. Conclusion:

Based on the discussion above, it can be concluded that the crop used the most energy when it was treated with Diclosulam 0.9% + Pendimethalin 35% SE 22.5 + 875 g ha-1, followed by Diclosulam 0.9% + Pendimethalin 35% SE45 + 1750 g ha-1. In contrast, the crop used the least amount of energy when it was in the control. Because the weed density was higher in the weedy check plot, the most energy used by the plant was noted. When weeding by hand, the least amount of energy was used. But in the hand-weeded treatment, the soybean seed and stover had the maximum N, P, and K content, while the weedy check had the lowest values. Diclosulam 0.9% + Pendimethalin 35% SE45 + 1750 g ha-1 had the highest N, P, and K content in soybean seed and stover, followed by Diclosulam 0.9% + Pendimethalin 35% SE 22.5 + 875 g ha-1. The experiment must be repeated for at least two to three years at the same and different location in order to confirm the current findings, as the conclusion was based on results from a single year.

5. References

Alexander M. 1977. Pulse Crop, Oxford and IBH publishing Co. Pvt. Ltd. Pp: 55.

AOAC. 1995. Official methods of analysis of the association official agricultural chemists, Washington, 4, DC. USA.

Bhargava BS and Raghupathi HB. 1984. Analysis of plant materials for macro and micronutrient, pp. 49-82. *In:* HLS Tandon (Ed.). Methods of analysis of soils, plants, waters and fertilizers.Fertilizer development and consultation organization, New Delhi.

Gomez AK and Gomez AA. 1984. Statistical procedure for agriculture research, II Edition, A Willey- International Science Publication. Indian Journal of Agronomy,53(4): 295-298.

Goplan C, Ramasastri BV and balasubramani SC. (1971). Nutritive value of Indian foods.National Institute of Nutrition, FCMR, Hyderabad.

Jha BK., Chandra R and Singh R. 2012.Influence of post emergence herbicide on weeds, Nodulation and yields of soybean and Soil Properties.Legume Research. 37(1): 47 - 54.

Leith H. 1965.Okologische Fiagestellumgen Beider Unterschung def biogischen Staff Production. 1. Qualitas Plant. Materiac Vegetablies12: 241-261.

Mishra JS, Singh VP and Yaduraju NT. 2002.Interference of common dayflower (*Commelinabenghalensis L*.) in soybean (*Glycine max (L*.) *Merrill*.). Indian Journal of Weed Science.34(3&4):294- 296.

Pandya N, Chouhan GS and Nepalia V 2005. Influence of integrated weed management on yield and economic viability of soybean (*Glycine max. L. Merrill*) varieties grown at different crop geometries. Indian Journal of Agriculture Science.;75 (8): 510-512.

Prachand S, Kalhapure A and Kubde KJ. 2015. Weed management in soybean with pre and post-emergence herbicides. Indian Journal Weed Science. 47(2): 163–165.

Tiwari SP. 2006. Plant introduction in soybean- achievements and opportunities. Indian Journal of Plant Genetic Resources 19: 353–65.

Vollmann J, Wagentrist H, Hart W 2010. The effects of simulated weed pressure on early maturity soybeans.European Journal of Agronomy. 32(4):243-48.