International Journal of Applied and Natural Sciences (IJANS)
ISSN(P): 2319-4014; ISSN(E): 2319-4022
Vol. 6, Issue 3, Apr – May 2017; 25-34

EFFECT OF PRESOWING SEED TREATMENT ON GROWTH OF WEEDS AND PERFORMANCE OF UPLAND RICE UNDER VARYING WEED SITUATIONS

C. V. SINGH[1], B.C. GHOSH[2] & R. K. SINGH[3]

[1]ICAR-Central Rainfed Upland Rice Research Station, Hazaribag, Jharkhand, India

[2]Department of Agricultural and Food Engineering,

Indian Institute of Technology, Kharagpur, West Bengal, India

[3]Krishi Vigyan Kendra (Holy Cross), Hazaribag, Jharkhand, India

ABSTRACT

Field experiments, aimed at minimizing the crop-weed competition in upland rice using non-chemical (seed invigoration) weed management practices, were carried out for two consecutive years during wet season at the research farm of Central Rainfed Upland Rice Research Station, Hazaribag, Jharkhand, India. Seed invigoration involved three thermal hardening (seeds subject to alternate temperatures; 43/28, 39/28, 35/28^{o}C), two hormonal priming (50 and 100 ppm GA_3), one nutrient priming (K-salt solution @ 4%) and one hydro priming treatment (wetting and drying).Untreated seeds were used in the control treatment for making comparison with aforesaid invigoration treatments. Two weed regimes were single and two hand weeding. Supplementary laboratory and tray studies were also carried out to optimize the seed treatments and corroborate the findings related to growth and vigor obtained from field experiments. Results revealed that thermal hardening attained subjecting seed to alternate temperatures (43/28^{o}C), seed priming, and hormonal priming with 100 ppm GA_3 proved better in weed suppression and produced higher grain yield than untreated seeds. Furthermore, integration of application of hormonal priming using GA_3 @100 ppm with thermal hardening improved rice productivity by influencing growth and yield attributes of rice and reducing the weed pressure due to improved crop-competitive ability Combining seed treatment with effective weed management proved successful approach for improving rice productivity.

KEYWORDS: Weed Control, Seed Treatment, Invigoration, Upland Rice, Crop-Weed Competition

INTRODUCTION

Rain fed rice is grown on 18 million hectares in eastern India. The weeds and drought constitute ‘‘the first stratum’’ of technical constraints (Namuco et al., 2009). A major portion of upland rice area (6.15 million hectare) in India is concentrated in the eastern states of Orissa, Jharkhand, West Bengal and Assam besides North eastern states. Weeds are estimated to reduce rice grain yields worldwide by 16%, and losses are considered greatest in rain fed crops, in which farmers are less able to manage water to suppress weed growth (Oerke et al., 1994; Rao et al., 2007).

Improving the ability of rice to sustain yields despite competition with weeds could have a substantial impact on reducing crop losses, particularly for those farmers with few resources and for whom the alternatives are scarce (Johnson et al., 1998). In direct-seeded systems, vigorous early growth of rice is considered to be particularly important, as weeds are a serious problem (Fukai, 2002; Widawsky and O’ Toole, 1996), and seedling vigor is one of the major determinants for successful crop establishment (Zhang et al., 2005).

Weeds reduce both the grain yield and quality of upland rice and estimates of yield losses by weeds in upland rice range from 30 to 100 percent. Although various cultural practices in upland rice production system may be adopted to minimize the weed infestation, each has its own merits and demerits. Conventional methods of weed control (manual and mechanical methods) are weather dependent, costly and labor intensive. Some of the herbicides are found to be very effective but indiscriminate use of chemicals may pose environmental problems (Cheema and Khaliq, 2000).Hence, integration of various weed control measures will help not only minimizing the use of herbicides but also optimizing economic returns to the grower.

Uneven crop stand provides less competition to weeds compared to good crop stand and hence, ensuring good population through better land preparation and use of different approaches viz., seed treatment with emergence/growth stimulants, pre-heat treatment, soaking and drying of seed etc. may help in minimizing density and biomass of the weeds in the fields. Ready and uniform germination of crop seeds and their development into vigorous crop seedlings leaves less space for the weeds to grow amongst the crop plants.

Seed soaking, sometimes followed by dehydration of seeds, has been demonstrated to improve subsequent germination of numerous vegetable seeds, especially under suboptimal conditions (Muhyaddin and Weibe 1989, Bradford 1986). Primed seeds usually exhibit an increased germination rate, greater germination uniformity, and, at times, greater total germination percentage (Basra *et .Al.*, 2005). Du and Tuong (2002) concluded that, when rice was seeded in very dry soil (near the wilting point), priming further increased plant density, tiller number, and grain yield. Incorporating plant growth regulators as part of presoaking, priming, and other presowing treatments of many crops resulted in improved seed performance (Miyoshi and Sato, 1997). Since information available on means of promoting early vigor in upland rice cultivars is scarce, field experiments and supplementary laboratory and net house studies were carried out to evaluate selective crop stimulation by various seed treatment methods. Their integration under different weed it further with the weed management practices.

MATERIALS AND METHODS

Field experiments, along with supplementary experiments (Lab/Tray studies), were conducted for two consecutive years at the research farm of the Central Rainfed Upland Rice Research Station, Hazaribag (23°56’46"N latitude and 85°21'46"E longitude), India under rainfed conditions. The soil of the experimental site was red soil with silty loam texture having pH 5.2, organic carbon 0.36%, available P 14.4 kg ha^{-1} and K 346 kg ha^{-1}.The climate of the location may be characterized as warm and sub-humid. The average annual rainfall of 1215 mm is received mostly (about 85%) from South West monsoon during June to October. The mean maximum temperature varied between 20.7 ^{0}C (January) and 38.2 ^{0}C (May) while the mean minimum temperature fluctuated between 5.2 ^{0}C (January) and 23.8 ^{0}C (July). The mean maximum relative humidity varied from 45.5 percent (April) to 89.3 percent (August), while the mean minimum relative humidity varied between 21.4 percent (April) and 84.8 per cent (August). Number of wet days varied from 53 to 55 days a year during cropping seasons of experimentation.

Supplementary laboratory and potstudies were conducted to optimize the pre-sowing seed treatments studying the effect of different cycles and periods of soaking seed along with other invigoration techniques like wetting and drying (water priming), thermal hardening, hormone and nutrient priming on seed leachates, germination and early growth parameters. Untreated seeds were used as control.

After treatment, seeds were given three washings with distilled water and re-dried near to original weight with forced air under the shade for 48 h. These seeds were then sealed in the polythene bag and stored in refrigerator at 5^{o}C before the use.

Seed priming (hydro priming), where seeds were soaked in water for 12 hours, thereafter dried under shade to attain original seed moisture. Nutrient priming involved soaking seeds in K-salt solution (4%) for 12 hours followed by drying under shade. Hormone priming, where seeds were soaked in gibberellic acid solution at two concentrations (50 and 100 ppm) for 12 hours, soaking was followed by drying under shade. In case of thermal hardening with alternate temperatures, seeds were subject to three cycles of 16 and 8 hours alternate high and low temperature cycle at three temperature ranges viz., 43/28 °C, 39/28 °C and 35/28 °C as per treatment in the oven. During second year of experimentation, treatment involving thermal hardening with 35/28 °C was discontinued due to poor performance in the first year and replaced by treatment integrating hormone priming with GA_3 at 100 ppm and thermal hardening (43/28 °C) in such a manner that later followed the former treatment. There were sixteen treatment combinations consisting of eight seed treatments and two weed control treatments (weedy check and 2HW) which were assigned in randomized complete block design and replicated three times. Sowing was done during the third week of June using a seed rate of 75 kg ha^{-1} of rice. Laboratory and pot studies were also carried out simultaneously to optimize pre-sowing seed treatment and provide logical support to results obtained from field experiments.

Calculations for germination related parameters were made using standard procedures as described by various researchers. Electrical conductivity of seed leachates was estimated by soaking 5 g seeds in 5 ml of deionized water at 25^{o}C. The EC was measured by a conductivity meter (Twin Cone Conductivity meter, Kyoto, Japan) and expressed as µS/cm/g. All data were subject to analysis of variance as per the standard procedure and least significant difference values were calculated at 5% significance level wherever the F-ratio was found to be significant.

RESULTS AND DISCUSSIONS

Seed Vigor

Laboratory and pot studies optimization of presowing seed treatments provided evidences of early emergence of seed from lower T50 and MET values in treated seeds (Table 1). Higher germination index and germination energy were recorded in treated then untreated seeds. Early growth of seedling was more in treated seeds both in laboratory as well as pot studies as exhibited by radicle and plumula length and weight of seedlings. Final emergence percent was also substantially more in treated compared to untreated seeds (Table 2).Early emergence as indicated by lower T50 and MET in treated seeds may be due to the faster production of germination metabolites (Basra *et. al.,* 2005; Lee and Kim 2000; Saha*et. al.,* 1990;) and better genetic repair, i.e. earlier and faster synthesis of DNA, RNA and proteins (Bray *et. al.,*1989).

Electrical conductivity of seed leachates is an indirect indication of seed vigor. Higher vigor seeds possess low EC of seed leachates. Figure1 shows the lower EC of seed leachates for the pre-sowing seed treatments and it is an indication of better membrane repair during controlled hydration. Priming treatments resulted in lower EC of seed leachates mainly due to improved membrane integrity in treated seeds as reported by Rudrapal and Nakamura (1988) for eggplant and radish, Basra *et. al.,*(2002) for wheat and Basra *et. al.,*(2003) and, Farooq *et. al.,*(2005) for rice.

Crop Growth

Data collected from field experiments indicated a progressive increase in plant height with the advancement of age reaching its peak at maturity. It was observed that the plant height at all the crop growth stages was significantly higher with seeds pre-treated with GA_3 at either 50 or 100 ppm (Figure 2 &3). However, at early stage, thermal hardening along with priming with GA_3 and also hardening by wetting and drying also showed significant increase in plant height. Weed control with 2HW has shown significant increased in plant height at all growth stages except at 20 DAS as compared to weedy check. Seed priming with water (SP) and thermal hardening (TH-43/28) showed significant increase in plant height at early growth stage. This effect of priming was substantiated by laboratory and pot studies (Table 4 & 5).

Crop biomass was significantly affected by different seed treatments at all growth stages in both years (Figure. 4 & 5). There was a progressive increase in crop biomass with advancement of crop age in both the years. In first year, hormonal priming using GA100 (HP-GA100) produced maximum biomass of the crop at 60 DAS and at harvest. At 20 DAS, the maximum biomass was recorded with primed seeds (PS) whereas biomass was highest with thermal hardening with alternate temperatures of 43/28 ^{0}C (TH-43/28) at 40 DAS during the first year. GA100 recorded maximum crop biomass at all stages in second year. Weed treatment did not influence crop biomass at 20 DAS in both the years. However, it differed significantly more in 2HW than weedy check at all growth stages in both years.

Weed Intensity and Biomass

Both the weed population as well as biomass, at harvest, were substantially less in plots where seeding was done using seeds treated using invigoration techniques such as seed hardening, nutrient priming with KCl and hormonal priming with GA_3(Table 3). Although thermal hardening treatment could not differ from untreated treatment during first year, combining thermal hardening and seed priming with GA100 showed significant reduction in dry matter. As expected, weed biomass was reduced significantly in plots weeded twice in 2HW treatment compared to weedy check. During both years of experimentation, a continuous increase in dry matter accumulation by weeds throughout the cropping season was observed as evident from Figure 6 & 7.

Different seed treatments achieved 6.5 – 21.6 percent weed control efficiency in first year and 9.4 to 23.1 percent in second year over untreated seeds. Weed population as well as weed biomass was significantly less at harvest in plots seeded using primed seeds. In first year of experimentation, seed hardening with wetting and drying of seeds (SP), and priming with nutrient (NP-KCL) or hormone (HP-GA100) reduced both weed population as well as weed biomass substantially. Combining thermal hardening (TH-43/28) with hormone priming (HP-GA100) caused significant reduction in weed biomass. Weed control efficiency achieved by different seed treatment techniques ranged from 6.5 to 21.6% in 1st year and 9.4 to 29.5% in 2nd year. Among weed control regimes, 2HW achieved 73.7 and 63% weed control efficiency in first and second year, respectively over weedy check.

Yield and Yield Attributes

Yield contributing characters were influenced by seed treatment. Different yield components and other associated character like panicle/m^2, grains/panicle and 1000 grain weight and length of panicle are presented in Table 2. The number of panicle /m^2 was found to be significantly higher in seeds treated with 100 ppm GA_3 during first year and GA_3, KCL and thermal hardening with GA_3 during second year. Different seed treatments did not show any significant variation in 1000 grain weight in both the years. The length of panicle was significantly higher in all treated than untreated seeds during first year of experimentation and seed treated with combination of thermal and GA_3 and GA_3 alone at 100 ppm. In weed management practices, all the yield attributes except 1000 grain weight were significantly superior to weedy treatment.

The effect of seed treatment on grain yield was more pronounced when seed was treated following seed priming with either water, KCL or by thermal hardening along with GA_3. Maximum increase of 0.37 t/ ha (average of 2 years) in grain yield was obtained in case of seed priming with GA_3 at 100 ppm. Combining thermal hardening (43/28 °C) with 100 ppm GA_3 resulted in highest productivity of rice during second year. Different seed treatments had positive effects on the straw yield as evident from increase in straw yield in both the years of experimentation.

The highest straw yield was achieved with GA100 during first year and with GA100 followed by TH-43/28 in second year. Both grain and straw yields were substantially increased by 2HW treatment over weedy check in both the years, Interactions among different seed and weed treatments were found to be non–significant in both the years. Positive correlation values were noted between tillers and grain yield and negative correlation between tillers and weed biomass (Table 3).

CONCLUSIONS

Rice seeds primed using seed hardening technique by wetting and drying seeds simply either with water or priming with nutrient (NP-KCl), hormone (GA100) or with combined application of thermal hardening (TH-43/28) fb HP GA100 produced higher grain yield than untreated seeds besides reducing weed pressure by producing more crop dry matter to improve crop-competitive ability. Combining seed treatment with effective weed management proved successful approach for improving rice productivity.

REFERENCES

1. Bradford, K.J. (1986). Manipulation of seed water relation via osmotic priming to improve germination under stress condition. HortScience, 21: 1105-1112.
2. Basra, S.M.A., M. Farooq and A. Khaliq. 2003. Comparative study of pre-sowing seed enhancement treatments in indica rice (*Oryza sativa* L.). Pak. J. Life Soc. Sci., 1: 5-9
3. Basra, S.M.A., M. Farooq, R. Tabassum and N. Ahmad, 2005. Physiological and biochemical aspects of seed vigour enhancement treatments in fine rice (Oryza sativa L.). Seed Sci. Technol., 33: 623–8
4. Basra, S.M.A., M.N. Zia, T. Mahmood, I. Afzal and A. Khaliq. 2002. Comparison of different invigoration techniques in wheat (*Triticumaestivum* L.) seeds. Pakistan Journal of Arid. Agriculture, 5:11-16.
5. Cheema, Z.A. and A. Khaliq. (2000), Use of Sorghum Allelopathic Properties to Control Weeds in Irrigated Wheat in A Semi-Arid Region of Punjab, Agriculture Ecosystems and Environment, Vol. 79, No. 2-3, pp. 105-112.
6. Du, L.V. and T. P. Tuang. (2002). Enhancing the performance of dry-seeded rice: Effects of seed priming, seedling rate, and time of seedling. In: Pande, S., Mortimer, M., Wade, L., Tuong, T.P., Lopes, K., Hardy, B. (Editors). Direct seeding: Research strategies and opportunities. International Rice Research Institute, Manila, Philippines. pp. 241-256.
7. Farooq, M, S.M., A. Basra, and K. Hafeez. (2005), Seed Invigoration by Osmohardening in Indica and Japonica Rice, Seed Science and Technology, Vol. 33, No. 3181-187.

8. Fukai, S. 2002. Rice cultivar requirements for direct seeding in rainfed lowlands. In: Pandey, S. Mortimer M., Wade, L. Tuong, T.P., Lopez, K., Hardy, B., (Eds.). Direct seeding: Research in Asian rice systems. 25-28 January 2000, Bangkok, Thailand, Los Banos (Philippines): International Rice Research Institute, p. 257-270

9. Johnson, D. E., M. Dingkuhn, M.P. Jones and M.C. Mahamane. (1998). The influence of rice plant type on the effect of weed competition on Oryza sativa and Oryza glaberrima. Weed research, 38: 207-216.

10. Miyoshi, K. and T. Sato. (1997). The effects of kinetin and gibberellin on the germination of dehusked seeds of indica japonica rice (Oryza sativa L.) under anerobic and aerobic conditions. Annals of Botany, 80: 479-483.

11. Muhyaddin, T. and H.J. Wiebe. (1989). Effects of seed treatments with polyethylene glycol (PEG) on emergence of vegetable seeds. Seed science and Technology, 17: 49-56.

12. Namuco, O.S., J.E. Cairns and D.E. Johnson. (2009). Investigating early vigor in upland rice (Oryza sativa L.): Part I. Seedling growth and grain yield in competition with weeds. Field Crops Research, Vol.113, pp. 197- 206.

13. Oerke, E.C., H. W. Dehne, F. Schonbeck and A. Weber. (1994). Crop production and crop protection: Estimated losses in major food and cash crops. Elsevier, Amsterdam.

14. Rao, A.N., D.E. Jhonson, B. Sivaprasad, J.K. Ladha and A.M. Mortimer (2007). Weed management in direct seeded rice. Advances in Agronomy, 93: 153-255.

15. Rudrapal, D. and S. Nakamura. 1988. The effect of hydration and dehydration pretreatments on eggplant and radish seed viability and vigour. Seed Science and Technology, 16(1):123

16. Widawsky, D.A. and J.C.O' Toole (1996). Prioritizing the rice research agenda for eastern India. In: Evenson, R.E., Herdt, R.W., Hossain, M. (Eds.), Rice research in Asia-Progress and Priorities. CAB International, Wallingford, Oxon, UK, pp. 109-130.

17. Zhang, X., Wang, D., Fang, F., Zhen, Y. and Liao, X. 2005. Food safety and rice production in China. Res. Agric. Modernization 26: 85-88

APPENDICES

Table 1: Germination and Early Growth of Rice as Influenced by Seed Hardening

Treatment	Cycle	T50 (days)	MGT (days)	FGP (%)	GI	GE (%)	Radicle Length (mm)	Plumule Length (mm)
Untreated Seed		1.52	3.16	67.4	21.0	76.4	42.6	44.9
Seed hardening 12 h	1 cycle	1.42	2.75	96.5	25.4	94.1	53.5	55.6
Seed hardening 12 h	2 cycle	1.36	2.68	98.9	26.7	96.6	52.8	58.2
Seed hardening 12 h	3 cycle	1.22	2.66	99.5	28.2	94.1	54.7	54.4
Seed hardening 24 h	1 cycle	1.32	2.26	97.4	26.6	94.2	56.7	57.8
Seed hardening 24 h	2 cycle	1.26	2.16	100.0	29.4	87.9	58.4	56.2
Seed hardening 24 h	3 cycle	1.34	2.65	98.7	28.2	90.4	52.8	54.5
LSD (p=0.05)		0.20	0.60	8.6	4.1	3.6	6.4	4.4

T50=Time to 50% germination, MGT=Mean germination time, FGP=Final germination percent, GI=Germination index,

GE=Germination energy

Table 2: Rice Emergence and Early Growth as Influenced by Seed Hardening

Treatment	Cycle	MET (days)	Root length (cm)	Shoot length (cm)	Seedling Fresh Weight (mg)	Seedling Dry Weight (mg)	FEP (%)
Untreated Seed		6.70	38.3	44.9	22.7	4.67	69.5
Seed hardening 12 h	1 cycle	5.50	46.4	55.1	33.6	7.56	88.3
Seed hardening 12 h	2 cycle	5.20	44.8	56.2	37.4	8.24	90.4
Seed hardening 12 h	3 cycle	4.80	47.6	57.3	34.9	7.66	85.5
Seed hardening 24 h	1 cycle	5.15	48.2	56.1	41.1	8.57	87.8
Seed hardening 24 h	2 cycle	5.09	47.5	55.9	39.6	8.42	94.1
Seed hardening 24 h	3 cycle	4.86	46.6	56.8	37.4	8.22	92.6
LSD (p=0.05)		0.90	4.4	8.2	7.2	2.3	12.4

MGT=Mean germination time, FEP=Final emergence percent

Table 3: Weed Dry Matter, Intensity and Floristic Composition as Affected by Different Seed Treatments and Weed Management Practices at Harvest

Treatment	Weed Intensity (no./m^2)		Weed Dry Matter (g/m^2)		Weed Control Efficiency (%)	
	Year-I	Year-II	Year-I	Year-II	Year-I	Year-II
Invigoration Techniques						
US	223	261	166.3	190.6	-	-
SP	191	236	136.8	158.8	17.7	16.7
NP - KCl	197	232	138.6	156.6	16.7	17.8
HP-GA50	185	214	132.6	144.6	20.3	24.1
HP-GA100	183	220	130.3	134.3	21.6	29.5
TH - 43/28	207	246	148.7	168.4	10.6	11.6
TH - 39/28	218	252	150.6	172.6	9.4	9.4
TH - 35/28 (Year-I); HP-GA100 fb TH - 43/28 (Year-II)	221	216	155.5	146.5	6.5	23.1
LSD (p=0.05)	18	18	24.6	28	-	-
Weed regimes						
WC	317	342	229.3	239.3	-	-
2HW	89	128	60.4	87.1	73.7	63.6
LSD (p=0.05)	29	26	38.4	38.4	-	-
US = Untreated seed, SP = Seed Priming, NP = Nutrient Priming, HP = Hormonal Priming,						
TH = Thermal Hardening with alternate temperatures, GA = GA3, WC = Weedy Check, HW = Hand weeding						

Table 4: Yield and Yield Attributes of Upland Rice as Affected by Different Techniques of Seed Treatment and Weed Control Methods

Treatment	Grain Yield (t ha^{-1})		Straw Yield (t ha^{-1})		Panicles (no. m^{-2})		Spikelets (no. Panicle^{-1})		Percent Sterile Spikelets		Weight Panicle^{-1}(g)		Lengthpanicle^{-1}(cm)	
	Yr. 1	Yr. 2	Yr. 1	Yr. 2	Yr. 1	Yr. 2	Yr. 1	Yr. 2	Yr. 1	Yr. 2	Yr. 1	Yr. 2	Yr. 1	Yr. 2
Invigoration techniques														
US	1.06	1.09	1.41	1.50	167	165	77	78	32.2	29.4	1.74	1.86	17.7	18.0
SP	1.18	1.38	1.86	1.93	192	197	80	79	30.5	26.8	1.86	2.00	18.3	18.9
NP - KCl	1.18	1.36	1.76	1.74	192	192	79	81	27.9	24.0	1.92	2.06	18.8	18.4
HP-GA50	1.25	1.39	1.98	2.23	201	195	83	84	28.0	23.0	1.95	2.08	19.0	18.6
HP-GA100	1.35	1.53	2.24	2.39	212	201	84	89	26.9	22.7	2.07	2.14	19.2	19.1
TH - 43/28	1.25	1.33	1.85	1.90	181	184	82	83	28.8	24.9	1.96	2.02	18.7	18.2
TH - 39/28	1.16	1.27	1.78	1.79	174	175	79	79	30.8	27.0	1.88	1.91	18.4	18.0
TH - 35/28 (Year-I); HP-GA100 fb TH - 43/28 (Year-II)	1.09	1.69	1.46	2.59	167	202	77	87	30.7	23.6	1.78	2.14	18.0	10.0
LSD (p=0.05)	0.16	0.26	0.25	0.44	35	23	3	2	1.5	2.2	0.06	0.20	0.4	0.8
Weed regimes														
WC	0.60	0.64	0.89	0.97	108	110	66	67	29.6	25.4	1.75	1.84	17.6	16.9
2HW	0.78	2.11	2.68	3.05	263	267	94	98	29.3	24.9	2.05	2.21	19.4	20.1
LSD (p=0.05)	0.32	0.56	0.41	0.83	53	48	9	2	ns	ns	0.22	0.26	1.2	2.8

US = Untreated seed, SP = Seed Priming, NP = Nutrient Priming, HP = Hormonal Priming, Yr. = Year,

TH = Thermal Hardening with alternate temperatures, GA = GA3, WC = Weedy Check, HW = Hand weeding

Table 5: Correlation of Certain Parameters with Grain Yield and Weed Biomass

Particulars	Correlation Coefficient "r"	
	Year I	Year II
Grain yield vs tillers /m^2	0.709*	0.642
Grain yield vs panicles/m^2	0.791*	0.692
Grain yield vs no. of grains/panicle	0.792*	0.807*
Grain yield vs test weight	0.689*	0.891**
Grain yield vs weed biomass at 20 DAS	-0.802*	-0.719*
Grain yield vs weed biomass at 40 DAS	-0.846*	-0.815*
Weed biomass at 20 DAS vs plant height at 20 DAS	-0.765*	-0.821*
Weed biomass at 40 DAS vs plant height at 20 DAS	-0.828*	-0.921**
Weed biomass at 20 DAS vs crop biomass at 20 DAS	-0.782*	-0.817*
Weed biomass at 40 DAS vs crop biomass at 40 DAS	-0.824*	-0.932**
Weed biomass at 60 DAS vs tillers/m^2	-0.782*	-0.816*
Weed biomass at 60 DAS vs panicle/m^2	-0.909**	-0.822*
*Significant at 5 per cent level, ** Significant at 1 per cent level*		

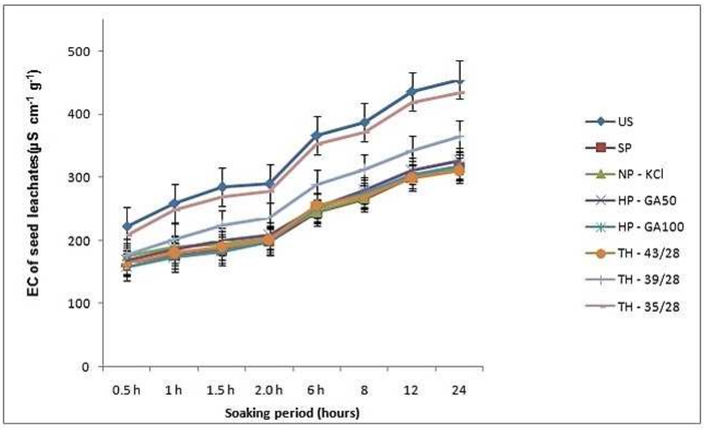

Figure 1: Effect of Seed Priming Treatments on the Electrical Conductivity of Seed Leachates (µS cm^{-1} g^{-1}) ±S.E

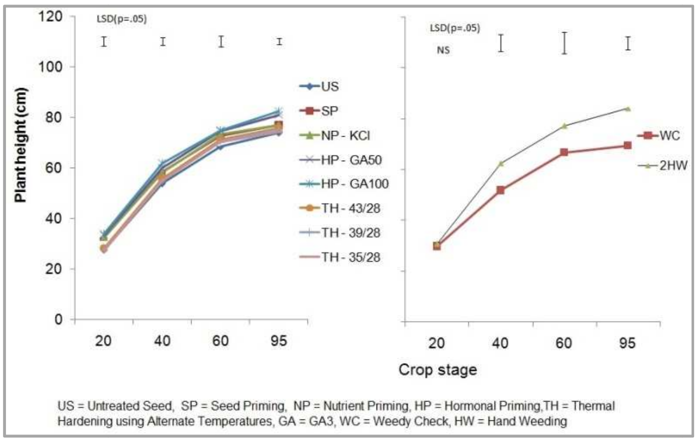

Figure 2: Plant Height (cm) at Different Crop Stages as Affected by Different Seed and Weed Management Practices (Year-l)

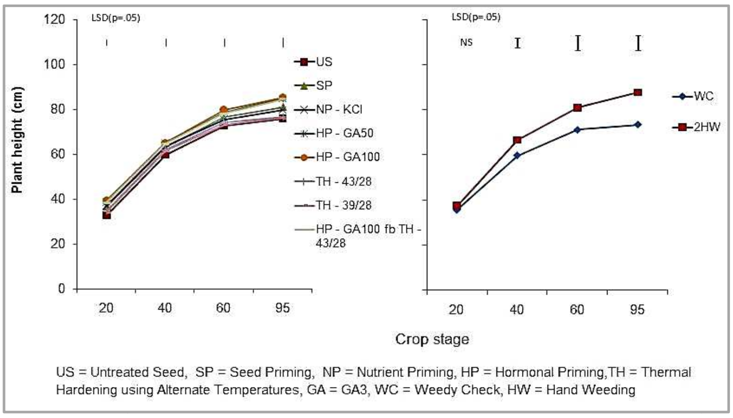

Figure 3: Plant Height (cm) at Different Crop Stages as Affected by Different Seed and Weed Management Practices (Year-ll)

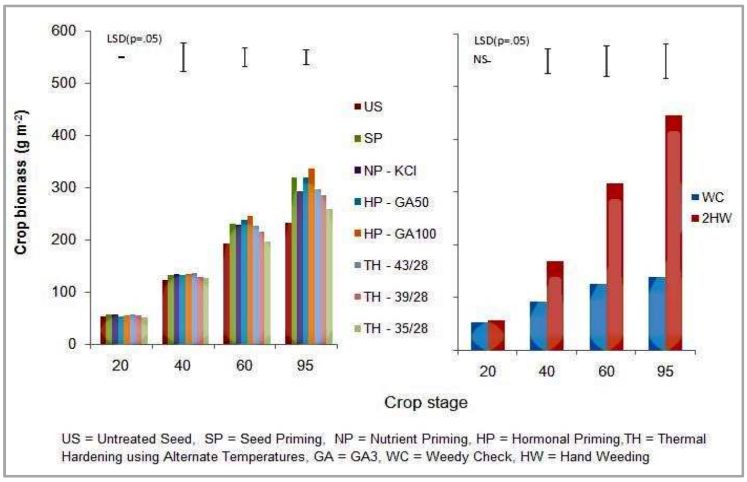

Figure 4: Crop Biomass (g m^{-2}) at Different Crop Stages as Affected by Different Seed and Weed Management Practices (Year-l)

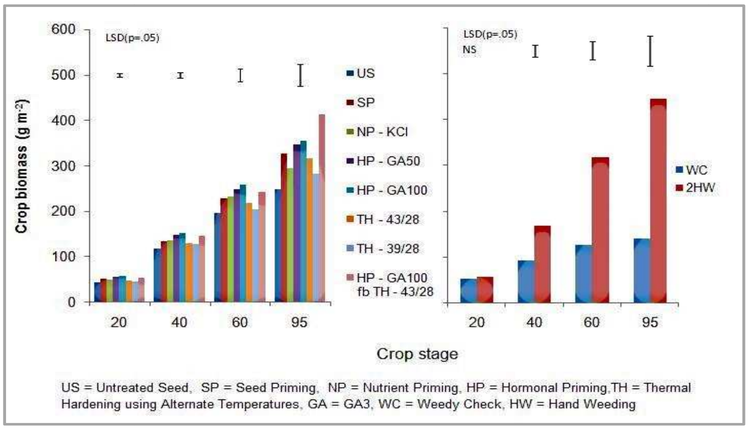

Figure 5: Crop Biomass (g m^{-2}) at Different Crop Stages as Affected by Different Seed and Weed Management Practices (Year-ll)

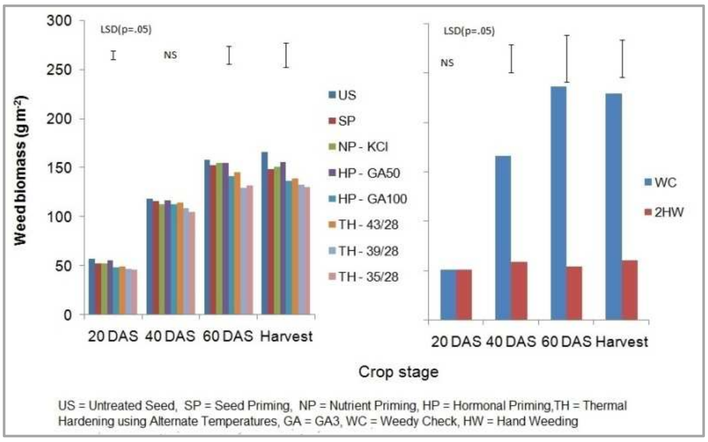

Figure 6: Weed Biomass at Different Crop Stages as Affected by Different Seed and Weed Management Practices (Year-1)

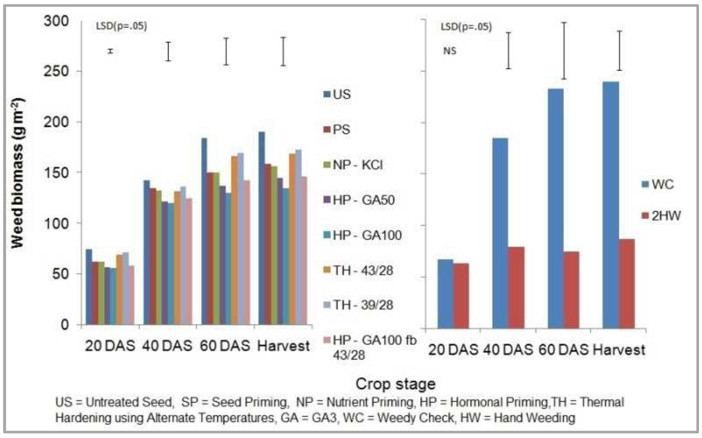

Figure 7: Weed Biomass (g m^{-2}) at Different Crop stages as Affected by Different Seed and Weed Management Practices (Year-ll)