Addressing water scarcity in dry seeded lowland rice

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Abstract

This study addresses the water scarcity issue in dry seeded lowland rice in humid tropics through a three-pronged approach compatible with the unique ecology of the production system. The first evaluated seed priming to ameliorate moisture stress in the early upland phase. The phytotonic effect of imidacloprid was reported for the first time in the study. The second developed a low cost and easily adaptable method of concurrent growing of green manure crops susceptible to water logging, and its subsequent incorporation. Finally, weed infestation, which increases the severity of moisture stress, was effectively controlled by biological suppression through concurrent growing of green manure crops as well as by the use of complimentary pre emergent herbicides.

Media summary

A total agronomic package was developed for addressing water scarcity issue in dry seeded lowland rice in humid tropics. It includes seed priming, a new low cost method of concurrent growing of leguminous green manure crops and integrated control of weeds involving biological and chemical measures.

Introduction

Rice is a unique crop amenable to cultivation under diverse situations of water availability. Dry seeded lowland (semi dry) rice is a major system of rice culture in humid tropics that integrates both aerobic and flooded ecosystems in tune with the water availability. It is a system that has been effectively tailored to the agro ecological characteristics of the growing region. Being a fragile ecosystem, significant deviations from the normal rainfall results in severe water stress and resultant yield reduction. In this context, a well-structured study was conducted at the Kerala Agricultural University, Thrissur, India to develop a comprehensive agronomic package in dry seeded lowland rice to address the water scarcity issue *per se* as well as the attendant ones.

Methods

The problems that emerge out of the water scarcity situations in dry seeded rice is manifested in three ways and hence a three-pronged approach was followed to address the problem

1.Amelioration of moisture stress in the early growth stage

Occurrence of early stage moisture stress leads to poor crop establishment and increased seedling mortality in the upland phase. Seed hardening /seed priming was attempted through laboratory and field studies to mitigate this problem. Seed priming was undertaken by soaking the seeds in water or solutions of different salts, fungicides, bio fertilizer, insecticide, nutrients, botanical extracts and cow dung at the rate of one litre solution per kg of seed for 18 to 24 h and drying them in shade to original weight

2.Development of a low cost green manure production system

Absence of standing water is a major constraint in organic manure addition, which over the years has reduced the water holding capacity of soils, resulting in early incidence of soil moisture stress. We attempted to develop a new method of concurrent growing of green manure crops and its incorporation that matches the water availability situations in the ecosystem. Three green manure crops viz., cowpea,

sun hemp and horse gram were tested in two phases for their effectiveness in nutrient contribution and yield enhancement.

3.Biological and chemical suppression of weeds

Absence of ponded water increases the weed incidence and exposes rice to severe competition for soil moisture and plant nutrients. Hence weed management was attempted through biological (concurrent growing of cowpea and horse gram as green manure crops) and chemical (application of pre-emergent herbicides viz., butachlor, pretilachlor, pendimathalin and anilofos) measures that are cost effective and complementary to the production system

Results

1.Amelioration of moisture stress in the early growth stage

Results of the laboratory and field experiments (Table 1) revealed the significant superiority of the hardened seeds in improving the various attributes such as speed of germination, germination percentage and seedling vigor that facilitated enhanced crop establishment in the field under adverse soil moisture conditions. Seedling mortality was minimal and seedling density was higher in treatments involving hardening.

Improved leaf water status and enhanced root growth was observed in the study which enabled hardened treatments to withstand drought better. Data on growth, yield and yield attributes indicated the superiority of the hardened treatments. Among the different treatments, priming with imidacloprid 0.05 % (an insecticide) recorded the highest grain yield, which was similar to azospirillum 2 %. Hardening with 1 % extract of the leaves of *Pongamia pinnata*, 2 % KH_2 PO_4 and KCl 2 % slurry were other treatments that recorded yields significantly higher than control. Priming with imidacloprid was found to be additionally advantageous since it expressed phytotonic effect on yield and reduced pest infestation. The phytotonic effect in the given context is defined as the additional positive advantages in growth and development other than the direct effect for which the input/process has been used and is reported for the first time in rice in respect of imidacloprid. The seed hardening effect due to the treatments has been steady and continuous up to the harvest, though the treatment was given to the seed before germination. The study conclusively proved that seed priming is a highly effective, low cost technology that can incorporate moisture stress tolerance and avoid yield loss in semi dry rice under adverse moisture conditions.

Table 1.Effect of seed hardening in dry seeded lowland rice

Treatment	Germination speed	Germination % (10 DAS)	Vigor index (15 DAS)	Seedling density- No.m^{-2} (27 DAS)	Root length - cm (15 DAS)	RLWC - % (60 DAS)	No. of panicle m^{-2}	Grain yield (kg ha^{-1})
Dry seed	3.98	82.4	1751	253.7	11.1	89.4	376	3199
Water	4.18	88.1	1772	284.7	11.2	88.5	394	3782
KCl 2 %	4.42	90.9	2942	327.0	18.0	92.1	456	4324
NaCl 0.5 %	4.23	90.2	2100	322.3	13.2	92.0	437	3998

KH_2PO_4 2 %	4.38	90.8	2146	297.7	13.3	92.9	418	4362
$ZnSO_4$ 1 %	4.20	90.4	1898	320.3	12.3	92.2	405	3910
Carbendazim 2 %	4.23	90.6	2141	286.0	12.9	90.0	389	3756
Imidacloprid 0.5 %	4.65	96.6	3473	395.7	20.2	92.7	470	5335
Cow dung (CD)10%	4.17	86.9	1912	241.3	11.7	89.7	392	3750
CD-wood ash 10 % each	4.23	90.7	2255	267.3	14.1	91.7	436	3765
CD-SSP10% and 1%	4.35	92.2	2262	278.0	13.9	92.7	420	4125
Azospirillum 2 %	4.50	94.8	3868	342.0	23.0	91.2	444	4638
Pongamia pinnata1%	4.45	94.5	3115	319.0	15.8	93.4	443	4306
CD (0.05)	0.22	6.4	429	61.4	0.6	2.4	47	810

2.Development of a low cost green manure production system

The study involved sowing of green manure crops i.e. cowpea and sun hemp in the first phase of the study and cowpea and horse gram in the second phase, as inter crops in between rice rows at the time of sowing of rice with the arrival of pre monsoon showers and allowing it to grow up to the onset of monsoon. Both the rice and intercropped green manure crop grow simultaneously up to around six weeks after sowing, benefiting from the few summer showers. By the time the monsoon sets in or canal water is released, water is allowed to pond in the field and the green manure crops were either manually incorporated or were allowed to decay in the standing water and get self incorporated in the field.

As compared to sun hemp, cowpea produced more biomass (12.6 vs.6.8 t ha^{-1}) and rice yield. So cowpea was found to be an ideal green manure crop for the system, when compared to sun hemp, because of its high initial growth rate, good canopy spread and easy susceptibility to water logging. With regard to the methods of incorporation, it was observed that the efficacy was comparable with regard to self and manual incorporations as observed by the yield (9.6 vs. 9.7 t ha^{-1}). In the case of self-incorporation, the leguminous green manure crop started wilting when water was ponded and completely decayed within 3-4 days and got incorporated in the field. Growth and yield characters and yield of rice was significantly superior to mono cropped rice, resulting in a yield increment of 0.6 t ha^{-1} (4.3 t ha^{-1} vs.3.7 t ha^{-1} for

intercropped and mono cropped rice, respectively). Practically no labour was involved for incorporating the green manure crop and hence it is a no cost technology that is well received by resource poor farmers to improve rice productivity even under water scarce situations.

Though cowpea was found to be an ideal green manure crop for concurrent growing under normal rainfall, it was found to have some disadvantages when there is undue delay in the receipt of southwest monsoon or canal water. Any delay in the incorporation of cowpea may lead to excess vegetative growth suppressing rice growth and adversely affecting rice yield. Excess growth may also cause problems in self-incorporation due to the poor susceptibility of the mature cowpea to water logging. The situation warranted further refinement of the technology and hence the second phase of the study was taken up with cowpea and horse gram as test crops.

In this study, there was a delay of around 10 days for water to pond in the field due to delayed monsoon, leading to difficulty in the self-decomposition and incorporation of green manure crops. The delay also led to overgrowth of cowpea causing competition to rice for nutrients, light and moisture and physical suppression of rice due to trailing habit. However due to lesser growth rate and bushy stature, horse gram did not cause competition to rice even when the incorporation was delayed. The grain yield of rice intercropped with cowpea was less by 0.2 t ha^{-1} than horse gram intercropped rice.

The biomass production by cowpea (28 t ha^{-1}) was significantly higher than horse gram (19 tha^{-1}) and is attributed to its quick growth rate (Bridgit et al., 1994). This was also reflected in nutrient addition. The contribution of NPK by cowpea was almost double that of horse gram (Table 2). In spite of this, the uptake of NPK by rice was found to be high in treatments intercropped with horse gram. As mentioned earlier it is attributed to the overgrowth of cowpea and the subsequent suppression of rice. The study thus revealed that under normal monsoons, cowpea is advantageous for inter cropping as green manure crop. Under situations of delayed monsoon, horse gram is a better choice over cowpea.

Substantial build up of soil fertility, with respect to NPK status, was observed in treatments involving intercropping as compared to monoculture immediately after the incorporation of green manure crops as well as after the harvest of the crop (Table 2). This indicated the positive influence of this new technology in sustaining the nutrient status of rice soils and subsequently enhancing rice productivity during current and succeeding crops. The technology is simple, low cost and suits different water availability situations

Table2. Concurrent growing green manure crops in dry seeded rice on nutrient addition and soil fertility status

Particulars	Rice + cowpea	Rice + horse gram	Rice alone
	Nutrient addition (kg ha-1)		
Nitrogen	103.7	56.2	-
Phosphorus	9.2	5.8	-
Potassium	55.1	28.2	-
	Soil nutrient status following green manure incorporation (kg ha-1)		
Nitrogen	454.0	404.8	374.2
Phosphorus	30.3	26.8	21.7
Potassium	223.1	201.1	172.5

Soil nutrient status after the crop (kg ha-1)

Nitrogen	227.2	233.5	219.5
Phosphorus	16.0	15.3	12.8
Potassium	83.9	75.8	68.7

3.Biological and chemical suppression of weeds

The overwhelming influence of concurrent growing of green manure crops on weed suppression was evident from the data (not presented) on weed population and dry matter production (DMP). Comparing the treatments intercropped with cowpea and horse gram receiving identical weed control measure, it could be seen that the total count and weed DMP were invariably high in treatments intercropped with horse gram (48.9 vs.84.7 weeds $m^{-2}$and 14.3 and 30.6 q ha^{-1} weed DMP for cowpea vs. horse gram). Comparing the un weeded plots, with cowpea and horse gram intercropping and rice mono crop, it was observed that intercropping reduced the weed count to the extent of 42.8 to 56.8 % up to 60 DAS and thereafter the rate of reduction declined. The added advantage, apart from an effective source of green manure, of concurrent growing of green manure crops in suppressing the weed infestation in semi dry rice is convincingly proved from the study. It was made possible by the shading of interspaces of rice plants by the vigorous growth of green manure crops, thereby discouraging the germination and growth of weeds. Musthafa (1995) reported that in cowpea intercropped fields, light penetration through the canopy is low, leading to low incidence of weeds.

The effect of chemical weed control measures on the count and DMP of the total weed population was found to be almost identical in both rice - green manure crop (cowpea and horse gram), intercropping systems, in spite of variation in the intensity of weed infestation. The data at 30 and 60 DAS revealed effective weed suppression in pendimethalin and pretilachlor treated plots, followed by butachlor, without any phytotoxic effect on rice as well as the intercropped green manure crops. Anilofos, however, failed to suppress weeds. Data at 90 DAS and harvest showed moderate to heavy weed infestation in all the treatments receiving pre emergence application of herbicides alone, revealing their failure to check the weed growth during the latter stages of the crop growth. In the case of most of the pre emergent weedicides, the residual effect lasted to around 45 to 60 days only. It may also be noted that the number and dry matter production of weeds was higher in hand weeded treatments, as compared to herbicides, except anilofos, at 90 DAS and harvest bringing out the effectiveness of herbicides over manual weeding in prolonged weed control. The study thus indicated that chemical weed control could be adopted safely and effectively in rice + green manure crop concurrent growing system provided the right herbicide is used. Pendimathalin and pretilachlor were observed to be the best herbicides while following the concurrent growing of green manure in semi dry rice.

Conclusion

Seed priming with identified materials was found to be effective in ameliorating early phase moisture stress in dry seeded lowland rice. A new low cost method of concurrent growing was developed for in situ production of green manures, which is subsequently incorporated simply by flooding, improving the water holding capacity of the soils. Biological suppression of the weeds through concurrent growing and use of herbicides complimentary to the system were also developed.

References

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