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The effect of foliar application of grass pea sprouts extract on yield, yield components, and grain quality of two rice cultivars

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Abstract
Germinated grains are a rich source of minerals, water-soluble vitamins, enzymes, and soluble sugars that can be applied by foliar spraying on the foliage of crop plants where photosynthesis takes place. A field experiment was conducted during the rice-growing season of 2020 to evaluate the effect of grass pea sprout extract on the growth and yield of two common local varieties of rice (Anbarbou and Shamshiri). The experiment was the 2 × 2 factorial combination of grass pea extract spray (2%) and rice cultivar. (based on the randomized complete block design with three replicates. Irrespective of foliar spray with grass pea extract, a significant difference between the two cultivars was observed for seed phosphorus and zinc content, and phytic acid concentration. Plants sprayed with the grass pea sprout extract significantly displayed greater net photosynthesis and water use efficiency. Grain yield, panicle number, grain number, grain weight, fresh and dry matter accumulation, and panicle length of plants at harvest increased up to 7.4%, 23.91%, 7.39%, 4.44%, 18.49%, 16.85%, and 26.5%, respectively, due to foliar application with the grass pea extract. Grain P content sprayed with the grass pea extract increased up to 65.38%, irrespective of the type of cultivar. Also, foliar spraying improved grain Zn content from 10.54 µg g^{-1} to 29.75 µg g^{-1}. Although, the grain phytic acid increased from 4.86 mg g^{-1} to 6.71 mg g^{-1} by foliar spraying of the grass pea sprout extract, however, the ratio of phytic acid to Zn content in the grain decreased from 46.11 to 22.55%. Foliar spraying increased grain Zn content in Anbarbou by 1.2-fold as compared to Shamshiri. On the other hand, foliar spraying increased grain phytic acid concentration in Shamshiri by 1.65-fold as compared to Anbarbou. It seems that spraying the rice plants with the grass pea sprout extract was beneficial in terms of agronomic and physiologic characteristics and nutrients such as Zn and P. Also, Anbarbou responded better to the sprout extract than the Shamshiri cultivar.

Keywords: Foliar spray; Grass pea extract; Phytate; Zinc

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Introduction

Foliar spray of nutrients has long been reported to increase the yield by enhancing plant photosynthesis efficiency and reducing fruit and flower shedding (Greer and Anderson 1965). Several studies showed that foliar spray with nutrients such as Fe and Zn in Psyllium (Behrouznajhad and Zehtab-Salmasi 2011), zinc in rice (Balakrishnan and Natarajarathinam 1996), phosphorus in green gram (Kalita 1989), boron in radish crop (Sharma *et al.* (1999), and N in blackgram (Elizabeth *et al.* (1988) lead to significant improvement in plant growth and yield.

Foliar application with seed extract has been subjected to several studies. Foliar application of sorghum seed extract at low concentrations has significantly increased biomass production, chlorophyll, proline, and seed yield (Al-Hussaini *et al.* 2013). It has been reported that seed extracts of horse gram (1%) and cowpea (3%) enhanced the yield of rice under field conditions. In another study, foliar application of black cumin seed extract improved maize growth (Hussain *et al.* 2021).

Lathyrus sativus L., (grass pea), a member of the *Leguminosae*, is known as rich in nutrients. Among legumes, grass pea is a drought-tolerant crop and foodstuff in drought-prone areas of the world. Grass pea biochemical characteristics have been subjected to several studies (Akpinar *et al.* 2001; Lisiewska *et al.* 2003; Emre *et al*. 2010). Grass pea seeds are rich in nutrients for human and animal nutrition. Grass pea contains magnesium, calcium, phosphorus, iron, calcium, phytic, thiamine, vitamin C, riboflavin, carotenoids, beta-carotene, and chlorophylls (Lisiewska *et al.* 2003).

Seed sprouting is the process of seed soaking, and then allowing the drained soaked seed to germinate (Veerappan *et al*. 2019). Soaking seed triggers the activation of enzymes, breaking proteins into amino acids, converting carbohydrates and fats into simple sugars, and creating water- soluble vitamins such as vitamin C and B complex (Vidal-Valverde *et al.* 2002; Veerappan *et al.* 2019). According to Augustin and Klein (1989), after seed germination, the content of potassium, zinc, and phosphors increases, however, Obizoba and Egbuna (1992) reported that Cu, Fe, and Zn increase in the germinating seeds but P concentration decreases. Germinating seeds are also a rich source of phytase (Eskin and Wiebe 1983) and α-amylase (Uriyo 2001). Eskin and Wiebe (1983) reported that phytate and phytase activity are changing during the germination of the Faba bean. Seaweed extract has been shown to act as a biostimulant for green gram (Kavipriya *et al.* 2011).

Rice micronutrient levels are among the factors that impact “hidden hunger” and food safety (Shi *et al.* 2020). Luo *et al.* (2020) reported that foliar application of ornithine significantly improved fragrant rice grain yield, seed-setting rate, 1000-grain weight, photosynthetic pigments, net photosynthesis, and grain protein content. Mo *et al.* (2016) applied different combinations of plant growth regulators, brassinolide, salicylic acid, fulvic acid, and calcium chloride on direct-seeded super and non-super rice seedlings and exposed them to chilling stress. There was a synergistic effect of all plant growth regulators on mitigating low-temperature stress in both rice types. The combination of various growth regulators improved seedling survival rates, seedling dry weight, root morphology, leaf area, and seedling height of both rice cultivars under low temperature by improving proline content, lowering lipid peroxidation, and modulating antioxidant enzymes. Saha *et al.* (2020) evaluated the possibility of enhancing zinc and iron bioavailability in 26 popularly grown rice cultivars. The application of zinc through the soil and foliar means could reduce the phytate/Zn ratio and improved Zn dense grains. Application of Zn fertilizers could also enhance the crude protein content of brown rice.

As compared to cereals, legumes are cultivated under the low chemical fertilizer input system. Therefore, organic sprout extract seems to be more suitable for these crops. Besides, seed extract is a cheap, eco-friendly, and feasible substitute for promoting plant growth (Veerappan *et al.* 2019). Thus, the objective of the present study was to evaluate the efficacy of foliar spraying of grass pea sprout on two traditional local rice cultivars (Anbarbou and Shamshiri) to achieve higher yield quantity and quality.

Materials and Methods

Experimental site

The field experiment was conducted during the rice-growing season of 2020 to study the effect of foliar spray with grass pea (*Lathyrus sativus* L.) extract on grain yield and yield components. The experimental site was situated between the longitude of 46°57′ east and the latitude of 33°78′ north with the altitude of 1050 m above sea level in the eastern part of the Ilam province, Iran. The site is characterized by a semi-arid zone with a mean annual rainfall of 466 mm.

Preparation of grass pea sprouts extract

Grass pea seeds were surface sterilized in 70% ethanol for 3 min and in 3% sodium hypochlorite solution for 10 min. Surface sterilized seeds were then rinsed several times in distilled water. Grass pea was then soaked overnight till sprouting. Sprouted seeds (100 g) were ground in a mixer-grinder, using 100 ml of distilled water. Sprout extract (100% concentration) was obtained by squeezing the ground substance through a cloth bag. Total soluble sugars and soluble protein content of the grass pea sprout were estimated following the methods of Dubois *et al.* (1956) and Lowry *et al.* (1951), respectively. Grain phosphorus content was determined according to the ammonium vanadate-molybdate method described by Chapman and Pratt (1961). Phytate concentration was measured according to Haug and Lantzsch (1983). Grain was first grounded. 0.2M HCl solution was used to dissolve the grounded grain. The solution was centrifuged for 30 min at 13000 rpm at room temperature. About 1 ml of the supernatant was taken and used for phytate concentration according to the method of Haug and Lantzsch (1983). Total nitrogen was measured, using the Kjeldahl method. Fe was estimated by atomic absorption spectrophotometry. Biochemical analysis of grass pea sprout extract showed total soluble sugars of 0.98%, soluble protein of 2.87%, and iron, zinc, nitrogen, and phosphorus content of 8.9, 78, 89, and 398 mg 100 ml, respectively.

Nursery growing and field experiment

The experiment was a 2 × 2 factorial combination of grass pea extract spray (2%) and rice cultivar (Anbarbou and Shamshiri) arranged in a randomized complete block design with three replicates. Grass pea sprouts extract was applied at the 2% concentration based on a preliminary in vitro and pot experiment. In a preliminary study, we studied the effects of foliar spray of grass pea sprout extract on the early growth of rice. A higher concentration of sprout extract was found to be toxic and led to a reduction in plant growth.

The seedlings of the two varieties were planted in a nursery near the main paddy field. Seeds were planted in the nursery with the local traditional method as follows: seeds were placed in gunny bags and put into the tap water for 48h. Gunnysacks of seeds were then placed under warm conditions to accelerate the seed germination. Seeds were then planted at the rate of 1.5 kg per plot of 2 m × 2 m in size. In all the nursery plots 500 g phosphorus per plot from the source of triple superphosphate was applied. The rice seedlings were grown in the nursery for 45 days and then were transplanted into the main field in standing water on 7th June 2020. Six seedlings per hill were transplanted into the puddle field at the plant to plant and row to row the spacing of 20 cm in a 2 × 3 m plot size. Nitrogen and phosphate fertilizer were applied to the main field at the rates recommended. All plots received 0.5 kg N ha^{-1} as urea (46%) and 0.5 kg $P_2 0_5$ ha^{-1} as superphosphate triple. Urea was applied in two equal splits, 250 g per plot at the time of transplanting as basal dressing and 250 g per plot before heading as a top dressing. The field was kept flooding with a water depth of 12 cm. Water in the main field was maintained by fresh water and was drained out every second day, according to the local traditional method. Foliar spraying with 2% grass pea extract was done at the early flowering stage (Boonchuay *et al.* 2013). Photosynthesis rate and the mineral status has been improved due to the foliar spray of organic extract at tillering and flowering stage in rice (Sultana *et al.* 2001). Unsprayed plots were sprayed with tap water.

At harvest, grain yield, panicle number per plant, seed number per panicle, and 1000-grain weight were recorded in each plot in the main field. To determine the grain yield, 1 m^2 of the inner rows from each plot was harvested at grain maturity. Spike number, kernel weight, and kernel number per panicle per plant were determined from a subsample of 5 plants from the interior row of each plot. At the flowering stage, net photosynthesis (P_N) and water use efficiency (WUE) were measured using a portable plant photosynthesis meter (Korea Tech Inc., Seoul, Korea). Soil Zn content was measured before the experiment was carried out. Seeds of both rice cultivars were analyzed for the zinc and phosphorus level. Seeds were also analyzed for phytic acid. P in seeds was determined by the vanadat-molybdate colorimetric method. Zinc in seeds was measured by the atomic absorption spectrometer method.

Statistical analysis

F-test was carried out to test the significance of treatment differences at 5% level of probability, using the PROC ANOVA procedure of SAS, by SAS software version 9.1. The least significant differences were calculated to identify the differences among treatment means at the 0.05 probability level.

Results

Effect of foliar spray with the grass pea sprout extract on grain yield and other agronomic attributes

Plant height, tiller number, leaf number, and leaf length of the two cultivars at the initial heading (just before foliar spraying) are shown in Table 1. Plant height was the only trait that was significantly affected by the type of cultivar.

The main effects of spraying with the grass pea sprout extract and rice cultivar and their interaction for grain yield, panicle number, grain number, grain weight, plant fresh weight, plant dry matter, and panicle length of plants at harvest are shown in Table 2. Interaction cultivar × foliar application was not significant for the above-mentioned traits. All of the traits were significantly affected by the foliar spraying. Grain yield, panicle number, grain number, grain weight, plant fresh weight, plant dry matter, and panicle length increased up to 7.4%, 23.91%, 7.39%, 4.44%, 18.49%, 16.85%, and 26.5%, respectively due to foliar application with the grass pea extract. The effect of cultivar on grain yield, grain weight, grain number, and panicle length was significant. The cultivar Anbarbou had significantly higher grain yield and grain weight as compared to Shamshiri. Anbarbou also produced heavier seeds than Shamshiri (Table 2). However, the panicle length of Shamshiri was significantly higher than Anbarbou.

Table 1. Plant height, tiller and leaf numbers per plant, and leaf length of two local rice cultivars (Anbarbou and Shamshiri) measured at initial heading, before foliar spraying with the grass pea sprout extract

	Plant height (cm)	Tiller number (g plant^{-1})	Leaf number (g plant^{-1})	Leaf length (cm)
Cultivar				
Anbarbou	110.6	5.68	15.96	31.33a
Shamshiri	103.7	5.81	13.96	31.66a
P-value in the ANOVA table	0.006	0.8	0.07	0.86
CV (%)	3	15.5	11.2	10.04

ANOVA: analysis of variance

Table 2. Grain yield, grain attributes, and grain Zn content of two rice cultivars (Anbarbou and Shamshiri) after foliar spraying with the grass pea (*Lathyrus sativus* L.) extract at the panicle initiation stage

Factors	Grain yield (kg ha^{-1})	Panicle number per plant	Grain number per panicle	Grain number per hill	Grain weight (mg)	Fresh weight (g plant^{-1})	Dry weight (g plant^{-1})	Panicle length (cm)
Foliar spray								
Sprayed	4904	5.7	89.94	3135	23.25	41.7	19.07	26.00
Not sprayed	4562	4.6	83.75	2204	22.26	35.19	16.32	20.55
Cultivar								
Anbarbou	4820	5.2	83.0	2587	24.86	39.3	17.9	21.5
Shamshiri	4635	5.1	89.3	2752	20.65	37.6	17.4	25.1
P-value in the ANOVA table								
Foliar spray (F)	0.0042	0.0015	0.0117	0.0022	0.0001	0.0002	0.0002	0.0004
Cultivar (C)	0.046	0.66	0.043	0.40	0.0001	0.088	0.20	0.0036
C × F	0.57	0.35	0.88	0.33	0.83	0.47	0.25	0.06
CV (%)	2.71	6.8	5.18	2.64	11.85	3.73	3.2	5.7

ANOVA: analysis of variance

Effect of foliar spray with the grass pea sprout extract on Zn, P, and phytic acid

The main effects of spraying with the grass pea sprout extract and rice cultivar for grain zinc and phosphorus content, and phytic acid of plants at harvest were significant (Table 3). Interaction of cultivar × foliar spraying with the grass pea sprout extract was significant only for grain Zn content and phytic acid but not for the grain P content (Table 3). The Zn concentration of Anbarbou was 17.29% higher than the Shamshiri cultivar. Foliar spraying with the grass pea sprout extract increased grain Zn content from 10.54 µg g^{-1} to 29.75 µg g^{-1} (Table 3). This increase was more pronounced in the Anbarbou cultivar as compared to Shamshiri (Figure 1). Irrespective of rice cultivars, foliar spraying with the grass pea sprout extract increased grain phytic acid by 38% (Table 3). The cultivar Shamshiri had a significantly higher level of phytic acid in seeds (29.9%) as compared to Anbarbou. Foliar spraying increased grain phytic acid concentration in cultivar Shamshiri by 1.65-fold but this increase was lower in Anbarbou (Figure 2). On the other hand, the ratio of phytic acid to Zn content decreased from 46.11 to 22.55%, averaged over the two varieties. P content of seeds sprayed with the grass pea sprout extract increased up to 65.38%.

Table 3. Grain zinc and phosphorus and phytate content of two rice cultivars (Anbarbou and Shamshiri) after foliar spraying with the grass pea (*Lathyrus sativus* L.) extract at the panicle initiation stage

Factors	Grain Zn content (mg kg^{-1})	Grain P content (%)	Phytate (mg g^{-1})
Foliar spray			
Sprayed	29.75	0.43	6.71
Not sprayed	10.54	0.26	4.86
Cultivar			
Anbarbou	21.7	0.32	5.01
Shamshiri	18.5	0.37	6.51
P-value in the ANOVA table			
Foliar spray (F)	0.0001	0.0001	0.0001
Cultivar (C)	0.0001	0.0198	0.0005
C × F	0.0001	0.3344	0.0272
CV (%)	1.76	7.8	6.3

ANOVA: analysis of variance

Effect of foliar spray with the grass pea sprout extract on P_N and WUE

Foliar spray with the grass pea sprout extract had a significant effect on P_N and WUE (Table 4). Although, the cultivar Anbarbou had higher PN and WUE as compared to the cultivar Shamshiri, this difference was not significant. There was also no significant cultivar × foliar spray interaction for these characteristics. Plants sprayed with the grass pea sprout extract displayed higher P_N and WUE (20.96 and 39% higher, respectively) as compared to the plants with no spraying.

Discussion

Grain yield and other agronomic attributes

The effects of foliar application on grain yield were similar in both rice types. Rice seed after foliar application showed higher grain yield than the untreated control, which could be attributed to the improved yield components, because grain

Table 4. Effect of foliar spraying with the grass pea (*Lathyrus sativus* L.) extract at the panicle initiation stage on water use efficiency and net photosynthesis of two rice cultivars (Anbarbou and Shamshiri)

Factors	Water use efficiency (µmol CO_2 mol^{-1} H_20)	Net photosynthesis (µ CO_2 m^{-2} S^{-1})
Foliar spray		
Sprayed	20.9	4.3
Not sprayed	15.0	2.5
Cultivar		
Anbarbou	20.4	3.75
Shamshiri	15.6	3.10
P-value in the ANOVA table		
Foliar spray (F)	0.033	0.048
Cultivar (C)	0.349	0.089
C × F	0.333	0.267
CV (%)	15.76	10.2

ANOVA: analysis of variance

weight, grain number per panicle, panicle number per plant, and panicle length were significantly enhanced due to foliar application with the grass pea extract. Increased grain number per panicle can be attributed to the higher panicle length in the rice plants. The present study supports the findings of Balakrishnan and Natarajarathinam (1996) who found that Zn application increased grain yield in rice. Improved yield components followed by foliar spray with the grass pea extract can also be attributed to the rich source of minerals present in the grain extract. It has been previously proved that germinated grains (such as pulses grain) are rich sources of minerals, water-soluble vitamins, enzymes, and soluble sugars (Augustin and Klein 1989; Vidal-Valverde *et al.* 2002; Veerappan *et al.* 2019).

In an experiment, the positive effect of horse gram and cowpea extracts on rice growth and yield has been previously reported (Veerappan *et al.* 2019), however, to our knowledge, this is the first report that has been elucidated the effect of grass pea as the sprout extract on rice growth and yield. We used the extract of sprouted seed because it has been reported that seed sprouting triggers the activation of enzymes, breaking proteins into amino acids, converting carbohydrates and fats into simple sugars, and creating water-soluble vitamins such as vitamin C and B complex (Vidal-Valverde *et al.* 2002; Veerappan *et al.* 2019) that can act as bioactive substances (Veerappan *et al.* 2019). It has been also reported that the organic extract provided from sprouting seed is rich in mineral nutrients such as N, P, K, Zn, Fe, and Cu (Augustin and Klein 1989), and phytase (Eskin and Wiebe 1983) and α-amylase (Uriyo 2001) that can be absorbed through the foliar application and results in the improvement of plant growth and yield (Veerappan *et al.* 2019). In the present study, grass pea extract contained total soluble sugars of 0.98%, soluble protein of 2.87%, and Fe, Zn, N, and P content of 8.9, 78, 89, and 398 mg 100 ml, respectively.

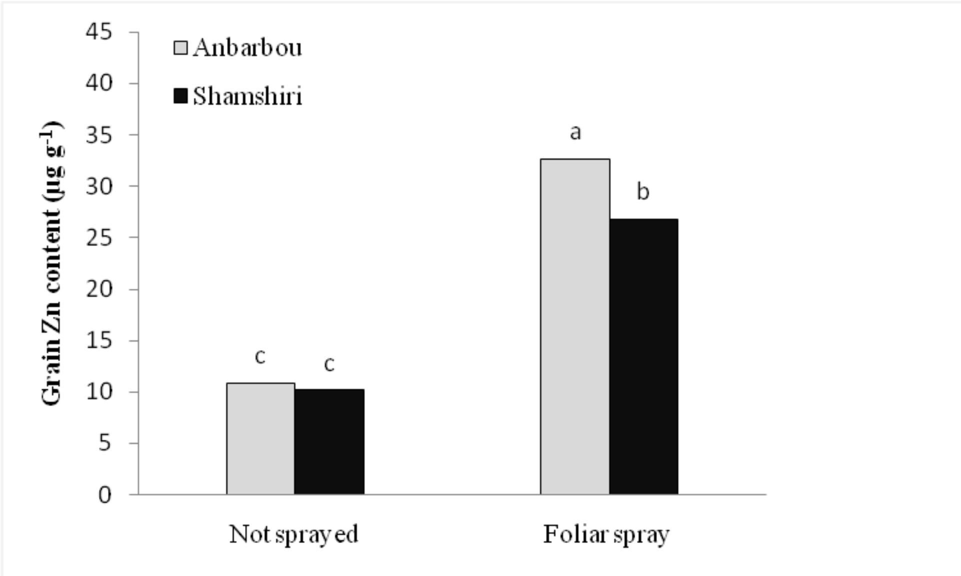

Figure 1. Effects of foliar spraying with the sprout grass pea extract on grain Zn content of two rice cultivars. Means followed by the same letter are not significantly different.

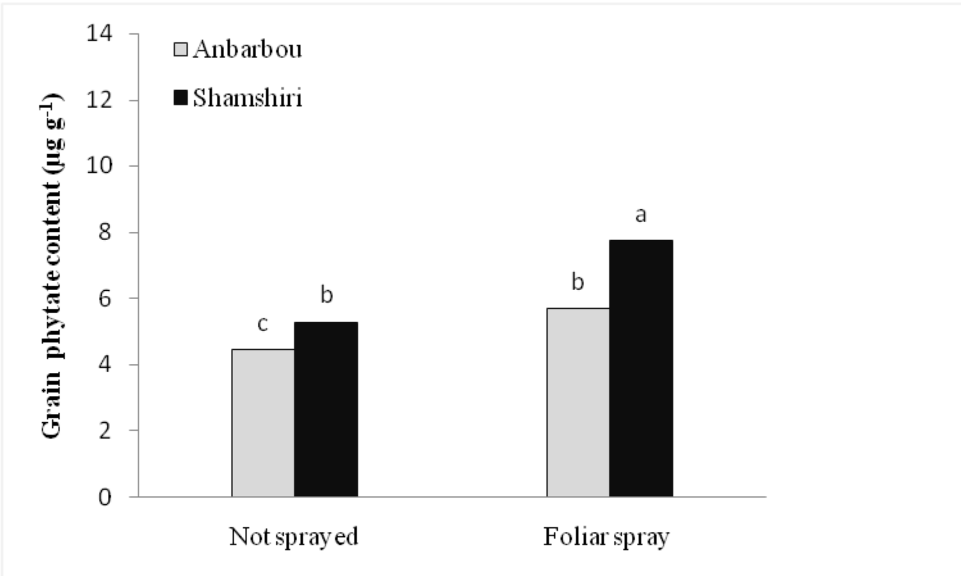

Figure 2. Effects of foliar spraying with the sprout grass pea extract on grain phytate content of two rice cultivars. Means followed by the same letters are not significantly different.

Sharma *et al.* (1999) reported that foliar application of boron increased the grain weight in radish. Foliar application of Zn solution has been reported to increase 1000-seed weight in cotton (Rathinavel *et al.* 1999). Zinc serves as a component of proteins and other macromolecules (Brown *et al.* 1993) and has an important role in carbohydrate metabolism (Rehman *et al.* 2012), protein and starch synthesis (Hoagland 1948), starch metabolism (Jyung *et al.* 1975), auxin synthesis (Tsui 1948), sucrose biosynthesis (Shrotri *et al.* 1980), the structural integrity of cytoplasmic ribosomes (Prask and Plocke 1971), phosphate metabolism (Reed 1946), and photosynthetic enzymes (Seethambaram and Das 1985). Enhancement in grain weight in this study because of the application of the grass pea sprout extract might be due to the improvement of translocation and accumulation of food reserves from sources (leaf and stem) to sink (filling grain).

Grain zinc, phosphorus, and phytate

Phytate is generally indigestible by monogastric animals. After translocation, phosphorus is stored in the form of phytate in the seed. Translocated P from the root, stem, and leaves to filling seeds would be converted into phytic acid, as the indigestible source of P for non-ruminants. It has been estimated that up to 80% of the total P concentration in seeds is converted into phytic acid. Phytic acid preserved in seed acts as a source of P and other cations for germinating seed and early seedling growth. Besides, phytate chelates various divalent cations. It has been reported that phytate chelates magnesium, copper, zinc, iron, and calcium in dietary phytate (Erdman *et al.* 1981; Holm *et al.* 2002). No study has been carried out to investigate the effect of foliar spray with bioactive substances extracted from the sprouted seeds on zinc, P, and phytic acid. Although the sprouted grass pea extract in this study resulted in an increase in phytic acid in seeds but also increased the grain Zn content. Micronutrients such as Zn are often limiting crop yields, especially in calcareous soils (Lakshmi *et al.* 2021). Besides, foliar spray with the grass pea extract also enhanced the phosphorus content in the seed. It has been found that in soil without Zn deficiency, the application of Zn reduces the phytic content of seeds (Yang *et al.* 2011). Soil Zn level of 0.8 mg Zn kg^{-1} has been suggested as the critical soil Zn level for the occurrence of Zn deficiency (Dobermann and Fairhurst 2000). The soil was not deficient in the plant's available Zn (28.98 mg Kg^{-1}) and the irrigation water contained 0.01 ppm Zn. Although, spraying with the grass pea extract increased the phytic acid of both cultivars but the ratio of phytic acid to Zn content in the grain decreased drastically (from 46.11 to 22.55). It has been reported previously that elevated seed Zn content through zinc fertilization reduced seed content of phytic acid (Saha *et al.* 2020). Overall, the effect of foliar spray with substances extracted from the sprouted seeds of grass pea improved agronomic characteristics and nutrients content such as Zn and P, and highly decreased the ratio of phytic acid to Zn content. Also, Anbarbou was a better-responding cultivar to the sprout extract than Shamshiri. Furthermore, it seems that besides the role of zinc in translocation and accumulation of food reserves from sources to sink, improved grain yield could be also attributed to the other properties of the grass pea sprout extract.

Net photosynthesis and water use efficiency

In this study, foliar spray improved net photosynthesis (P_N) and water use efficiency (WUE). The improvement in P_N and WUE may partly be attributed to the effect of zinc existing in the grass pea extract. Zn involves in various physiological processes such as carbohydrate metabolism (Rehman *et al.* 2012). The improved number of grains per panicle and panicle number per plant in this study was presumably due to improved P_N and WUE.

Conclusions

The present study represented the promising effect of foliar spraying with the grass pea sprout extract to increase the grain Zn content, seedling growth, and yield of the transplanted rice. Foliar application of the grass pea sprout extract (2%) had also a significant effect on grain phosphorus and phytate. Although in this study, the grass pea sprout extract increased the phytic acid of the seeds but also increased drastically the grain Zn content, resulting in a large decrease in the ratio of phytic acid to Zn content.

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Conflict of Interest

The authors declare that they have no conflict of interest with any organization concerning the subject of the manuscript.

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تاثیر محلول پاشی با عصاره خلر بر عملکرد، اجزای عملکرد و کیفیت دانه دو نوع رقم برنج

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چکیده

دانه جوانه زده منبع غنی از عناصر، ویتامین‌های محلول، آنزیم ها و قندهای محلول هستند که می‌توانند به صورت محلول پاشی برگی روی گیاهان زراعی مورد استفاده قرار گیرند. آزمایشی به منظور بررسی تاثیر عصاره استخراج شده از دانه جوانه زده خلر بر عملکرد و اجزای عملکرد دانه دو رقم برنج، شمشیری و عنبربو، تحت شرایط مزرعه‌ای در سال زراعی ۱۳۹۹ طرح ریزی شد. آزمایش در قالب فاکتوریل ۲ × ۲ با محلول پاشی عصاره (۲٪) و بدون محلول پاشی روی دو رقم مذکور در سه تکرار پیاده شد. صرف نظر از محلول پاشی برگی، میزان فسفر، روی و اسید فیتیک دانه در دو رقم متفاوت بود. محلول پاشی با عصاره استخراج شده از دانه خلر موجب افزایش میزان فتوسنتز خالص و کارایی مصرف آب در هر دو رقم برنج شد. عملکرد دانه، تعداد خوشه، تعداد دانه در خوشه، وزن هزار دانه، میزان وزن خشک و تر و نیز طول خوشه تحت محلول پاشی برگی با عصاره خلر به میزان ۷/۴، ۲۳/۹۱، ۷/۳۹، ۴/۴۴، ۱۸/۴۹، ۱۶/۸۵ و ۲۶/۵ درصد افزایش یافت. محلول پاشی با عصاره حاصل از دانه خلر موجب افزایش ۶۵/۳۸٪ محتوای فسفر دانه، صرف نظر از نوع رقم شد. **همچنین** محلول پاشی با عصاره خلر موجب افزایش میزان روی دانه از ۱۰/۵۴ به ۲۹/۷۵ میکرو گرم در کیلوگرم شد. **اگرچه اسید فیتیک دانه از ۴/۸۶ به ۶/۷۱ میلی گرم در گرم با محلول پاشی عصاره گیاهی افزایش یافت، ولی نسبت اسید فیتیک به روی از ۴۶/۱۱ به ۲۲/۵۵ درصد کاهش یافت.** محتوای روی دانه در رقم عنبربو در نتیجه محلول پاشی به میزان ۱/۲ برابر بیش از رقم شمشیری افزایش یافت. **از سوی دیگر محلول‌پاشی با عصاره دانه جوانه زده خلر، میزان اسید فیتیک دانه را در رقم شمشیری ۱/۶۵ برابر نسبت به عنبربو افزایش داد. به نظر می‌رسد که محلول‌پاشی گیاه برنج با عصاره دانه جوانه زده خلر از نظر بهبود صفات زراعی و فیزیولوژیکی و نیز مواد مغذی مانند روی و فسفر مفید بوده است. همچنین رقم عنبربو نسبت به شمشیری به عصاره دانه جوانه زده واکنش بهتری نشان داده است.**

واژه‌های کلیدی: اسید فیتیک؛ روی؛ عصاره خلر؛ محلول پاشی

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